LONG STRUCTURAL ZONES IN THE

ARCHAEAN YILGARN CRATON,

WESTERN AUSTRALIA

by

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DECLARATION

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ABSTRACT

Eight structural zones from 250km to 800km long, traverse the granite-greenstone terrane of the Eastern Goldfields and Murchison districts of the Yilgarn Craton. The structural zones, herein called LSZ, (long structural zones) have been traced using 1:500,000 geological compilations and AGSO (Australian Geological Survey Organisation) aeromagnetic and gravity data.

LSZ are complex linear deformation zones, resulting in the reactivation of structures formed prior to a craton wide shortening episode. Some of the pre-existing structures are interpreted as low angle extensional features, post dating the formation of much of the supracrustals; others as still earlier structures controlling original volcanic and sedimentary greenstone belt architecture.

The structural corridors reactivated by the shortening event are overprinted by strike-slip faults which formed relatively narrow shear zones within the corridors.

Most of the LSZ contain or abut linear belts of relatively coarse, immature, locally derived clastic sediments, which have been in turn overprinted by shear zones. Carbonate and alkali metasomatism is commonly strongly developed within the local sediment troughs.

Numerous alkalic syenitic plugs have been intruded within and adjacent to the LSZ. At larger scales, several LSZ are associated with K-Th-U rare metal (W-Sn-Be-Li)rich granitoids, or alkali rich syenites in belts up to 250km long.

LSZ contain a record of the youngest events related to the evolution of the greenstone-granite terrane; the youngest sediments, the belts of clastics; the youngest shear zones; and the youngest intrusive suites.

LSZ are direct hosts to only a few large Yilgarn gold deposits. Several major deposits occur within structures directly connected to LSZ. Although major, deeply penetrating crustal scale structures, LSZ are not a necessary or sufficient condition for the formation of major gold deposits in the Yilgarn.

1.0 INTRODUCTION

The most important part of this report is the three half million scale geological interpretation maps. An outline of the processes used in compiling and interpreting geological and geophysical data is given in Appendix 1, and major sources are listed in Appendix 2.

The maps were produced to investigate, at regional scales, the relationships between major structures, the distribution of greenstones and granitoids, and the occurrence of major gold deposits, and to develop targeting principles for such deposits.

For proprietary reasons, the main emphasis of this report is not the distribution of gold deposits or their target signatures.

The maps together with aeromagnetic and gravity data sets at the same scale, can be used to examine various large scale features of the Yilgarn Craton (including the distribution of gold deposits). The subjects explored in this report are firstly the relationships at the northern margin of the craton, which is obscured by Proterozoic basins; and at the western boundary of Murchison Province. Secondly, the tracing of some of the major "lineaments" or "tectonic zones" through the granite-greenstone terrain.

Several compilation maps of the Yilgarn, or significant parts of it, are available; eg. WASM (1990); Gemuts (1987).

Almost every publication about the geology or mineralisation of the Yilgarn contains a figure showing major faults and greenstone belts. These maps do not correctly show the location of the major structures, or the outlines of the greenstone belts. Most compilations have not used the large amount of available subsurface information, or geophysical data, in particular gravity data. (See Appendix 1).

In this report the course of the longest "lineaments" herein called by the non genetic term "long structural zones" (LSZ) are traced from one end of the craton to the other, and their surface expressions fixed as accurately as possible.

To make such descriptions possible without a superabundance of geographic names, northings are used to define points or segments along the course of each structure. The "reliability" of the interpretation varies from place to place across the maps; due to the variable quality and density of data, and structural-lithological complexity. However the regional scale patterns of distribution of rock types, and the outlines of greenstone belts as presented, are essentially correct.

To avoid obscuring details of the Archaean geology Proterozoic dykes are omitted from the maps as are most of the vast swarm of short "lineaments" interpretable from remote sensing data, eg. Hunting, (1975). These lineaments trend approx 050° and 330° and are the expression of "post cratonization" early Proterozoic dilation; clearly shown by intrusion of large numbers of continuous linear mafic-ultramafic dykes.

At present there is no consensus as to which is the most appropriate tectonic model for the Archaean Yilgarn Craton evolution. Unlike the Archaean greenstone-granite belts of the Superior Province, Canada, which are interpreted to be the product of accretionary tectonicsl Card (1990); Taira et al (1992); Jackson et al (1994); Clowes (1994) the Yilgarn is ensialic, and early extensional tectonics has been important; Hammond and Nisbet (1992); Williams and Whittaker (1993); Passchier (1994).

Recognition of the presence of low angle structures and the possibilities for their reactivation is important for rationalising some of the complexities of the LSZ such as opposed movement sense in adjacent sectors; variable plunges of extension lineations; and interaction of vertical and transcurrent movements in adjacent sectors, or parts of the same sectors.

However this report does not attempt to evaluate tectonic models for the Yilgarn. Neither does it attempt to provide a detailed structural model for the LSZ; this has only been done in a few locations eg. Eisenlohr (1989); Passchier (1994), and the general applicability of these models is not proven. This is mainly a product of poor exposure within the LSZ.

The aim is to prove the continuity of the LSZ and to locate them as accurately as map scales and geological/geophysical data allow.

Pre-existing nomenclature for the Yilgarn LSZ has been retained where possible. While there is no apparent consistency - various LSZ are called lineaments, faults, or tectonic zones - these terms are mostly well known and entrenched in the literature.

2.0 MAJOR STRUCTURES IN GREENSTONE-GRANITE BELTS - LSZ

The paradigm for greenstone belts, that they consist of relatively coherent slices separated by "long" and "deep" faults has been in operation since the early days of systematic mapping of the Archaean in Western Australia and elsewhere Gee (1979), Groves et al (1989); Verncombe et al (1988); Colvine et al 1988; Eisenlohr et al (1993). Such structures have been described as deformation zones; Colvine et al (1988); craton scale lineaments or large scale shear zones; Eisenlohr et al (1993); crustal scale faults, or tectonic zones; Hallberg (1985) or high strain zones; Verncombe et al (1988). In this report the "structures" are called LSZ (long structural zones) as a purely descriptive term. As the above suggests the nature and even the existence (?) of LSZ have been controversial subjects. It is probably safe to conclude that the LSZ in the Yilgarn Craton have had a complex history and are composite, as are the Canadian (Abitibi Belt) Destor - Porcupine and Larder Lake - Cadillac "Breaks"; Jackson and Fyon (1991); Hodgson et al (1990).

Recent syntheses; Card (1990); Williams et al (1992); Taira et al (1992); Lafleche et al (1991); Jackson et al (1994) tend towards an island arc-accretion model for the Archaean greenstone belts of the Superior Province; ie the craton consists of a collage of "exotic" terrains. Mapping in the Eastern Goldfields Province of WA, Swager et al (1992); Swager (1993); has also suggested that a collage of different terrains exists there, although syntheses have stopped short of a full plate tectonic style accretional interpretation. In such "accretionary" models the LSZ, at least in part, are interpreted as terrain boundaries.

A recent east-west seismic profile across part of the Eastern Goldfields has led to a new emphasis on the role of extensional tectonics based on the seismic interpretation of listric faulting, and subsequent inversion; Golbey et al (1993); Williams (1993). As in the Superior Province; Jackson et al (1990), the Goldfields seismic work detected significant horizontal layering within and below the greenstone sequence; Golbey et al (1993). This is in accordance with structural models emphasising thinskinnned (thrust) tectonics; Martyn (1987); Archibald (1987) Swager (1989). The significance of extensional low angle structures has also been emphasised by Hammond and Nisbet, (1992, 1993) Williams and Currie, (1993). These authors interpret at least some of the LSZ as being steepened, reactivated early extensional low angle structures (LAGS).

There is no direct evidence to suggest that major Archaean shear zones (LSZ) flatten with depth in the Yilgarn or elsewhere. Drilling and mining has shown that steep dips are maintained for the depths so far reached; (in Abitibi "breaks" over 2kms) at the Kolar Mine, India, structures steepen to vertical at depths of 3.2 km; Siddaiah and Rajamani (1989). Moderate dipping structures are, of course, known eg. Granny Smith; Ojala et al (1993); Sons of Gwalia; Tattan (1953), but it is clear that there is no direct evidence that LSZ to "go listric" at depth.

2.1 Nature of LSZ

Where studied in detail at surface the LSZ are steeply dipping shear zones, consisting of single or anastomosing strongly foliated zones with subordinate mylonites. Strain is very heterogeneous; with lenses of texturally well preserved rocks common within strongly foliated zones. Lineations are often subhorizontal; Libby et al (1990); but local steep to vertical lineations are common, especially close to granitoid contacts.

Complex patterns of ductile deformation overprinted by brittle-ductile deformation have been documented in areas where detailed structural mapping has been done; Wang et al (1993); Eisenlohr et al (1993); Verncombe et al; (1989); Eisenlohr (1989).

Within LSZ, felsic porphyry dykes, lamprophyre dykes, pegmatites and linear "buck" quartz bodies are common. The LSZ often contain regionally extensive zones of carbonate alteration, isotopically distinguishable from that directly associated with gold mineralisation.

LSZ commonly occur along the margins of late clastic filled basins (such as the Kurrawong Beds) or are marked by elongate sediment packages; (KKL, CF, BBF, CL). The structures have partly controlled the shape of, and sedimentation within the basins. There has been later movements along the LSZ as shear zones occur within troughs and linear sediment packages.

Post tectonic granites are also affected by shearing along the LSZ eg Wang et al (1993).

Exposure of the LSZ is generally poor. Detailed work has been concentrated in areas of good exposure (which tend to be opencut mines). Few studies have attempted to generalise the detailed structural results and apply it to LSZ at craton scales. Exceptions are the work of Libby et al (1991);Eisenlohr (1989); and Eisenlohr et al (1993).

Their conclusions are that the LSZ in the Yilgarn, in general have the following characteristics:

1. North-northwest trending LSZ show major sinistral displacement, commonly with late relatively minor dextral movement; north-northeast faults have dextral displacements.

2. North-south trending segments are mainly zones of flattening with little displacement.

3. Movement is mainly strike dip

4. LSZ are zones of complex heterogeneous deformation

5. LSZ are late in the Yilgarn deformation history.

Poulsen et al (1992) recognise a pattern of "faults" in the Superior Province with east-west structures being high angle reverse or dextral strike-slip faults; and north-east and north-west faults having sinistral and dextral displacements.

This pattern is analgous to that outlined in 1 and 2 above and is interpreted to be related to a major phase of transpressional tectonics. Poulsen et al (1992); Eisenlohr et al (1993).

While most regard the LSZ as zones of significant transcurrent displacement, others regard them as mainly steepened, low angle structures ie. "lag" surfaces; Hammond and Nisbet (1992); formed during early large scale crustal extension. If this model is applicable the LSZ could also be reactivated transfer faults in the sense of Lister et al 1986 ie. parallel to extension direction. Similarly transfer faults operative during north-northwest directed thrusting (D_1 of Swager (1989); Swager and Griffin (1990) may be reactivated to form LSZ.

Overall it is apparent that the LSZ may be at least in part reactivated structures which originally played important roles in controlling evolution of the greenstone belts.

2.2 Recognition of LSZ

In the various regional scale data sets, LSZ can be traced by one or more of the following criteria:

1. late conglomerate troughs

2. mapped belts of shearing along linear greenstone-granite contacts

3. mapped belts of shearing or strongly developed foliation within greenstone belts.

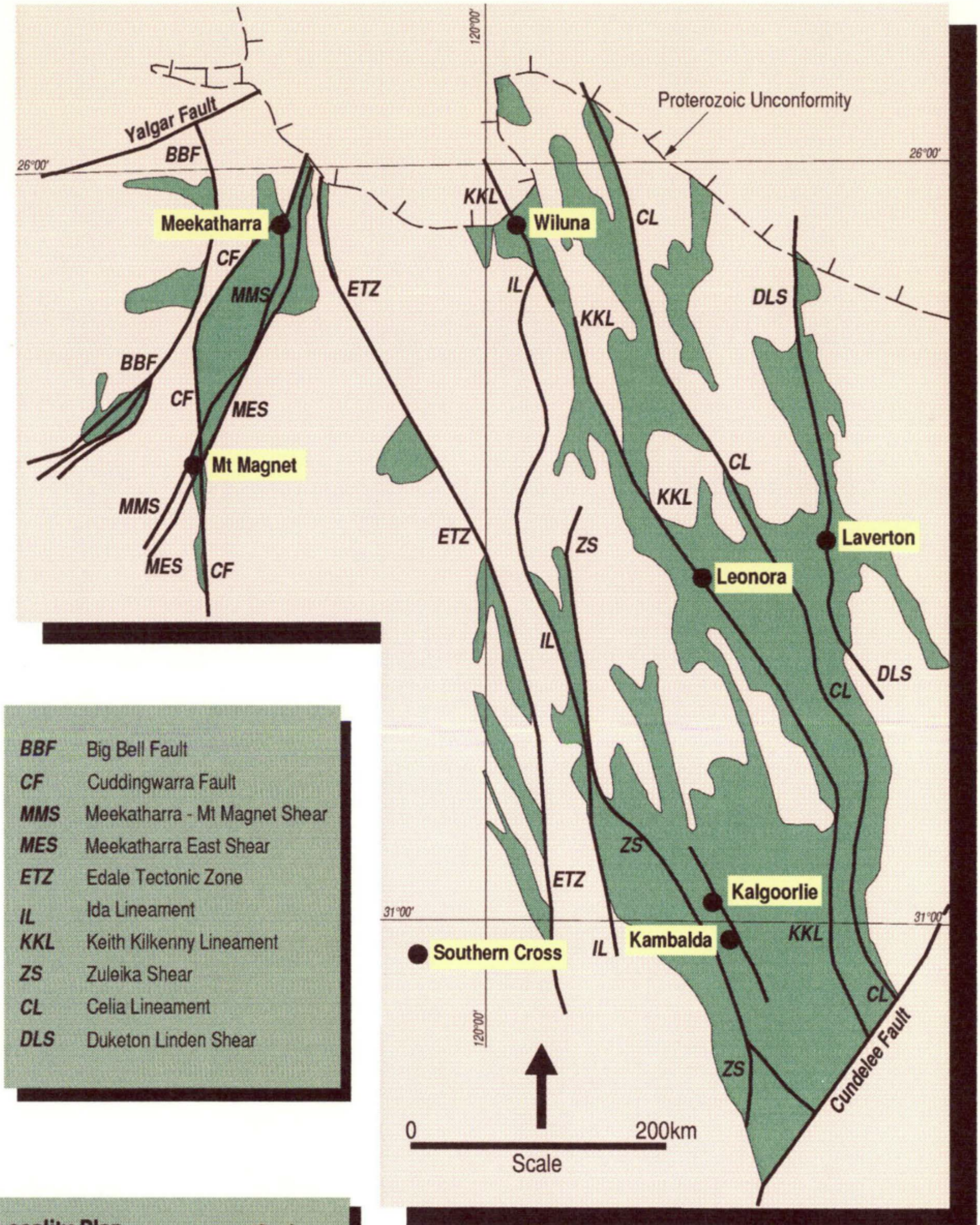
4. alignments of quartz "blows" or dense quartz float on Landsat images or air photos.

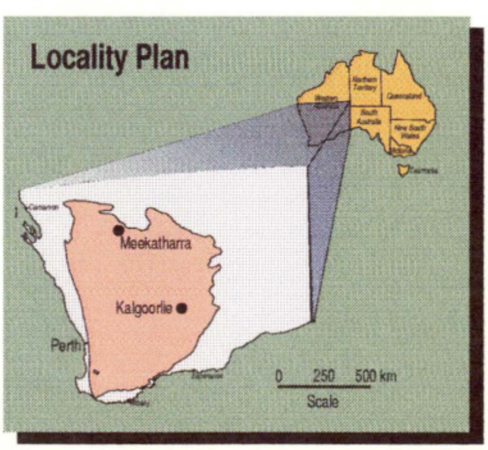
5. aeromagnetic alignments or truncations - "aeromagnetic lineaments"

6. gravity alignments or linear high gradient zones

7. geological discontinuities - terrain boundaries

8. magnetic destruction zones in granitoids





Long Structural Zones (LSZ) of the Archaean Yilgarn Craton W.A.

W223-139

Features of LSZ	DSL	CL	KKL	ZS	ETZ	MES	MMS	CF	BBF
Separates sectors of marked different geology	✓	✓	✓	✓	✓	✓	✓	✓	✓
Elongate clastic troughs	✓	✓	✓	✓				✓	
Contains small felsic intrusives or has alignments of late granitoid intruisons adjacent	✓	✓	✓						
Abundant carbonate ± alkali metasomatic zones	✓	✓	✓	✓		✓	✓	✓	✓
Truncate regional folds	✓	✓	✓	✓	✓			✓	✓
Significant gold mineralisation within LSZ or directly linked	✓	✓	✓			✓	✓		✓

3.0 THE DUKETON-LINDEN SHEAR (DLS)

This shear zone can be traced by geological mapping and aeromagnetic data over 300kms SSE from its northern limit under Proterozoic cover. Overall the DLS has a 345^{O} trend, with alternating north-south and north-northwest trending sectors. Limited field observations and aeromagnetic interpretations indicate a consistent dextral displacement. The shear dips consistently steeply east. It is the most easterly of the LSZ identified in this study.

The trace of the main shear zone is marked on Plates 1 and 2.

At its emergence from under Proterozoic cover (7032000N) the DSZ forms the sheared western margin of the Duketon North greenstone belt, and trends north-south. Further north (under Proterozoic cover) the contact swings north-northwest. The shear zone is about 3km wide separating granite gneiss (west) and a sediment-mafic package. Talc-chlorite and chlorite schist form the sheared greenstone margin. Displacement is dextral. South of 6992000N the shear zone swings north-northwest and follows a tightly constrained greenstone "neck" joining the North and South Duketon greenstone belts. The neck consists of sheared mafic and banded iron formation (bif) north-northeast to north-east striking vein sets in adjacent granitoids indicate dextral movement in this sector also.

South of 6960000N the DLS enters the South Duketon greenstone belt; the shear is marked by a poorly exposed belt of strongly foliated rocks and "buck" quartz veins parallel to the strike of the shear. The DLS separates two sectors of the greenstone belt; a mafic plus sediment - bif package to the east and an intermediate felsic volcanic package to the west. Between 6932000N and 6905000N sheared granitoids occur in the shear zone; the zone of deformation is up to 3kms wide.

The western arm of the greenstone belt has a strong gravity signature which is sharply truncated by the north-northwest trending structure near 6900000N; north-northwest trends terminate against the north-south shear zone.

Between 6900000N and 6850000N the shear zone is approximately central to a relatively narrow greenstone belt, confined to the eastern margin of an andesite volcaniclastic unit and bif. The eastern sector of belt is a set of shallowly north plunging granite cored antiforms.

South of 6806000N the DLS bifurcates; the eastern strand continues south-southeast, marked by a 2km wide sheared granitoid slice, and dissipates in a series of splay faults along granite contacts (6815000N). Dextral displacement along this strand is reported by Keele (1992).

The western strand enters a complex structural zone, with a north-south trending fault separating a folded mafic ultramafic - bif package (west) from a sediment-andesite package (east). Lancefield gold mine is located 3kms west of the N-S fault. Several north-south faults "link" the main fault strand to a fault bounded partly sheared polymict conglomerate unit (6886000N) about

1km wide which marks the southern continuation of the DLS. The eastern boundary of the conglomerate is commonly a mylonite zone; Hallberg (1985).

Mapped geology and gravity indicate that the DLS is a break between a coherent mafic-ultramafic package to the east, the Merolia Sector of Hallberg (1985) and a highly deformed andesite-sediment-bif sequence to the west. Overall the conglomerate unit is concave to the west in the north, swinging to concave in the south and trending north-northwest south of 6780000N. The DLS truncates units on either side; deflections of magnetic markers define dextral displacement.

South of 6790000N the western boundary of the DLS is a strongly sheared bif unit, (Sunrise Dam BIF) which does not crop out but is evident on magnetics.

South of the swing in trend to SSE (6780000N) the clastic sediment unit is sheared out; the Merolia sector mafic sequence is increasing attenuated against the shear zone, and finally completely pinched out between the Linden granite (west) and gneiss-migmatite (east).

Between 6801500N and 6775000N the DLS is overprinted by northwest trending brittle faults with minor if any displacement; these are parallel to the Honman Fault to the south (6735000N).

Little is known about the detailed structure of the shear zone apart from the consistent steep easterly dip of foliation. Keele (1992) has reported east block down (reverse) movements along a sector of the structure (6825000). No estimate of lateral displacement can be made as there are no obvious "matches" of lithological packages.

The structure is a late feature; the conglomerate unit contains granite and greenstone clasts; Hallberg (1985) and is itself foliated and contains mylonite zones. Folds are truncated by the DLS. A major carbonatite intrusion occurs close to the DLS (Mt Weld 6806000N 455000E); dated ≈2020Ma; Duncan and Willett (1990). Its presence within 2kms of the DLS is evidence that the DLS is an important crustal structure.

3.1 Mineralisation

Significant gold mineralisation occurs within or adjacent to the DLS; at Ehrliston District (Duketon South Belt) 6902000N 435000E; Lancefield, Laverton district 6840000N 439000E and at Sunrise Dam, 6785000N; 447000E. Additionally many lesser gold occurrences and prospects occur along the DLS.

For the districts noted above the significant structural relationships with DLS are - for Ehrliston the truncation of a northwest gravity trend by the north-south DLS; for Lancefield, the presence of a major "kink" in DLS and interaction with early layer parallel structures; for Sunrise Dam the occurrence of an anticlockwise bend in the DLS.

4.0 THE CELIA LINEAMENT (CL)

On aeromagnetic and gravity images, and regional geological compilation (Plates 2 and 3) the Celia Lineament can be traced as a complex structural zone over 800 kms south south-east from the limits of Proterozoic cover at 7150000N. The northernmost sector of the CL shows Proterozoic? reactivation; as the Horse Well Fault, a major "buck quartz-filled" structure, it offsets iron formations in the Nabberu Basin. Interpretation of aeromagnetic data suggests that within Archaean basement to the Nabberu Basin (North of 7150000N) the north-northwest fault trends splays and interacts with 300° trending basement structures (Plate 2). From the Proterozoic margin (7150000N) to 7130000N the CL corresponds to the mapped Horse Well Fault and is a shear zone within greenstones. South of 7130000N the CL forms a zone several kilometres wide of foliated gneiss and greenstone, marking the eastern margin of the Millrose Greenstone Belt.

Exposure in this sector is poor, but widespaced drill holes show that much of the greenstone belt is strongly foliated; aeromagnetics indicate that ultramafic units in the belt are strongly attenuated. Between 7040000N and 7080000N the CL swings from north-northwest to north-south, reverting to a north-northwest trend at 7060000N. At about 703000N the Millrose belt, the eastern arm of the Jundee Greenstone Belt, is truncated by a 320° structure which merges with the CL. In the sector described above the CL separates two distinct terrains. East of the CL is a corridor 20-30km wide containing an abundance of relatively small granitoids intruding gneissic granite. The plutons can be readily delineated by magnetics, but the gravity pattern of discrete ovoid lows also clearly defines this belt. There are also several (enigmatic) highly magnetic complexes, 7090000N 270000E, 7110000N 290000E, mapped as granitoid; Elias and Bunting (1976), which have a relatively high gravity signature. Rather than granitoid, they may be segments of mafic gneiss bounded by early extensional "lag" faults. cf Hammond and Nisbet (1992). This chain of granitoids is contiguous with the alkalic intrusive belt described by Libby (1989). Aeromagnetic and gravity signatures indicate that the alkaline intrusive belt continues along the eastern margin of CL in the sector described above, and includes the Teague Ring Structure, described as a high level alkaline intrusive complex; Johnson (1991).

Between 7020000N and 6980000N is a complex necking zone linking the Jundee and Yandal Greenstone Belts. The western margins of both the neck and the Jundee Belt have sharp linear gravity signatures, in contrast to the shallower irregular gradients along the eastern margin. The linear western margins could be upturned reactivated extension lag faults as suggested by Hammond and Nisbet (1992). From the west to east the 10km wide neck comprises a 3-5km wide mafic sequence, shear bounded on the west dipping 70° east; a 2-5km wide variably deformed granitoid sheet; and a 2-3km wide foliated mafic belt.

Between 702000N and 700000N the neck is overprinted by 300° linear faults with minor sinistral displacement.

A strand of the CL continues along the sheared, steep west dipping east margin of the Yandal Greenstone Belt to 6910000N. Several other shear or fault zones can be traced within a 10-20km wide zone of ovoid granitoid intrusives between the Yandal Belt and the granite-gneiss complex to the east; Laverton Domain of Williams and Whitaker (1993). The most obvious "break" is between the gneissic granite of Laverton Domain and the complex of ovoid granitoids, south to 6860000N. In this sector the CL is entirely within granitoid; it marks the steep west dipping margin of the domal Laverton Domain and is interpreted as a reactivated early extensional "lag" structure; Williams and Whitaker (1993).

South of 6860000N to 6810000N the CL is within the narrow Mt Zephyr-Mt Koorong Greenstone Belt. Exposure is poor but drilling and detailed aeromagnetics allow definition of several shear zones. The most westerly of these separates northeast striking units of the Kilkenny Syncline; Hallberg (1985) from the northwest trends of Mt Zephyr-Mt Koorong belt. Strands of the CL structurally bound the greenstone belt; it is separated from, and is lithologically different from, sequences in the Mt Margaret Anticline to the east and Kilkenny Anticline to the west. The difficulties of "correlating bif units from the Mt Margaret area were noted by Hallberg (1985). In this sense the entire Mt Zephyr greenstone belt is part of the CL.

At Mt Morgans, shear zones are focused into komatiite units where the greenstone belt narrows between granitoids (6815000N); these shears overprint a layering parallel fabric with intrafolial folds and bedding parallel isoclinal folds; Vielricher (1993); Williams and Whitaker (1993). The Mt Zephyr-Mt Morgans greenstones may be equivalent to the Windarra sequence and be part of the "roof" sequence of an extensional dome; Laverton Domain of Williams and Whitaker (1993).

South of 6815000N the CL swings to 170° and passes along the eastern margin of the Eucalyptus Anticline. Exposure is poor, but detailed aeromagnetic interpretation defines a 3-5km wide zone of "breaks", rotated blocks and layering terminations. Sinistral movements are indicated; Langsford (1990); Keele (1992). Small scale strike faulting and tight folding has been mapped immediately west of the CL on the eastern limb of the Eucalyptus Anticline; Hallberg (1993a).

A feature of this sector of the CL south ot 6750000N is the presence of more than 20 "pinpoint" magnetic anomalies which are interpreted to be small plugs of either magnetic syenites or peridotite. Several broader magnetic features (6775000N, 425000E; 6759000N, 428000E) are interpreted to be the expression of non exposed magnetic granitoid intrusives. Radiometrics show strong potassium signature coincident with the magnetic features; Langsford (1990).

Along the 170° trending sector a series of northeast to north-northeast shear splays from the CL; these form the contact between the eastern limb of the Margaret Anticline and a 20km wide andesite and sediment dominated sequence which is bounded on the east by the Duketon-Linden Shear.

At 675000N the CL is intersected by a zone of west-northwest sinistral faults; movement post dates the late granitoids; Hallberg (1993a). The Honman Fault is the most obvious of these. Other effects include the sinistral deflection and termination of bif-dolerite "couplets"; ie. north of the faults the characteristic bif-dolerite association disappears although bif continues; Langsford (1990).

South of 6750000N the CL marks the boundary of two distinctly different assemblages; a west facing mafic dominated package to the west, and an east facing, east dipping bif-mafic-andesite package to the east. (Edjudina Range bif sequence). The presence of the CL as a major dislocation is shown by the following relationships interpreted from mapping; Hallberg (1993) and aeromagnetic data. The CL truncates the extensive zone of hornfelsing and porphyry dyking around the southern margin of the granite (6750000N to 6740000N); a dismembered layered sill occurs along the CL (675000N); and the CL truncates a small granitoid intrusive (outlined by an aeromagnetic high halo) at 6700000N. Further south the CL wraps around the eastern margin of a major ovoid granitoid. Here the CL corresponds to the Claypan Fault; Williams (1970); Swager (1993a). In the sector described above, deflections of lithological layering, defined by aeromagnetics, indicate sinistral movement. Sinistral movement on the Claypan Fault was also determined by Swager, (1993). The CL south of the Pinjin Monzogranite of Swager (1993), (666000N) swings from a north north-west to north-south orientation, traceable to 6570000N, marked by a belt of shearing, quartz blows and zones of silicification; Smithies (1994). South of 6570000N, the CL swings to a north-northwest orientation and forms the western limit of a granitoid dominated domain, the Erayinia Granitoid Complex of Griffin and Hickman (1988). A strong gravity gradient reflects the contrast across the CL with greenschist grade greenstone sequence to the west, and close packed ovoid granitoids with narrow amphibolite grade greenstone "screens" to the east. In this sector the CL affects post D2 granitoids dated at 2665 ±7My, Smithies (1994).

Between 6660000N and 6570000N the CL is coincident with Claypan Fault of Swager (1993) and Smithies (1994). The CL is a zone of intense vertical foliation up to 1km wide, parallel to lithological layering to the east but strongly transgressive to the layering west of the CL.

In this sector both the CL and KKL swing from north north-west to north-south trends and are only 5-10kms apart. The greenstones are strongly deformed, with reactivated low angle structures, and intruded by east-west dykes and major quartz veins oriented northeast and northwest; Smithies (1994). Considering that the sector is bounded by two major structures, intense deformation is not unexpected.

Alkaline syenites have been intruded along both the KKL and CL in the north-south trending sector; they are late intrusives (2629-2471Ma) and are interpreted to be intruded along "deep seated crustal structures"; Johnson (1991).

South of 6570000N the CL can be traced on gravity and detailed magnetics as the boundary between a domain dominated by ovoid strongly magnetic grantioids to the east, and a mafic volcanic dominated domain to the west.

The CL can be traced by geological mapping, aeromagnetics and gravity from the northern to southern limits of the exposed Yilgarn greenstone-granite terrain. Over part of its length it is a shear zone with a significant sinistral strike slip component; elsewhere it appears to be reactivated early low angle structures. It is associated with numerous splay structures and northwest to northeast late brittle fault zones. Along its entire length the CL is associated with late intrusives; oxidised syenitic plugs and dykes; ultramafic plugs; lamprophyres and alkaline syenites; Libby (1989), Johnson (1991); the sinistral strike-slip episode can be seen to post date the "post folding" D2 granitoids. The regional compilation shows that the CL along its entire length separates sectors with differing geology.

4.1 Mineralisation associated with the CL

Significant gold mineralised centres occur within and close to the CL.

At Horse Well (7141000N) gold mineralisation occurs within carbonate altered sheared mafics, surrounding a major quartz vein which is a late brittle fault component of the CL.

The Darlot Field (6915000N 335000E) is hosted in massive tholeiitic basalt immediately west of the western strand of the CL; (granite-greenstone contact) the local controls are gently north-northwest plunging folds and northwest to north-northwest fault splays from the western strand of CL. Numerous lamprophyres along these secondary structures testify to a linkage with crustal scale structures.

At Mt Morgans gold occurs within bif and mafics, adjacent to a belt of sheared ultramafics which is a strand of the CL. The mineralised centre is controlled by a complex interaction of an early extensional event;

Williams and Whittaker (1993) with later shearing involving reactivation of the steepened early structures. Numerous lamprophyres also occur in CL in this district.

Between 680000N and 6750000N several centres of alluvial and minor vein style gold centres occur along the CL. South of this, no gold mineralisation has been located close to the CL. Over much of this sector the CL has a very linear track.

In the Laverton District, significant gold mineralisation occurs along north-east to north-northeast structures linking the CL and DLS. The most important is the Granny Smith Mine, which is located at a local flattening of the host shear, within a more northerly trending segment of the shear. The main link fault, the Laverton Fault (LF) separates a mafic sequence (west) from an andesite dominated sequence (east) and truncates the south plunging Mt Margaret Anticline.

4.2 Significance of the CL

The CL has proved fairly difficult to trace in its northern part (north of 6900000N) due to lack of information (which is a consequence of very poor exposure). However the feature which indicates that the CL is a major regional structure is the consistent association with a corridor of ovoid granitoids, some of which are known to have alkaline affinities; Johnson (1991) and a characteristic aeromagnetic and gravity expression. (Unfortunately no detailed aeromagnetic data were available in this sector for this study). Johnson (1991) interprets the alkaline intrusives to be related to a "deep rift". The occurrence of lamprophyres along the CL has been previously mentioned; numerous small dipole aeromagnetic features along CL between (6815000N and 6750000N) are interpreted to small intrusive plugs of magnetic syenite or peridotite.

Further south several more alkaline syenite intrusive occur within or adjacent to the CL; Johnson (1991). The most obvious expression, therefore, of CL as a "deep crustal" feature is the consistent association with intrusives interpreted to be of "deep crustal" origin. It does not appear to have the regional carbonate alteration association of the Zuleika Shear (ZS) or the persistent association with late conglomerate troughs as has the Keith-Kilkenny Lineament (KKL).

It does share with these others LSZ the property of truncating folds and separating different geological sectors, and a has direct link with gold mineralisation over the northern half of its length.

There is evidence for late activity along the CL; the alkaline syenites are dated (Rb/Sr) at 2630-2470 Ma by Johnson (1991); these must be treated with caution but suggest a relatively late age for these intrusions compared with "normal" post tectonic monzogranites ≈2665 Ma; Campbell et al (1993).

Some Proterozoic reaction is indicated by Post Nabberu (1700Ma) movement on the Horse Well Fault, and alkaline syenites in the Teague Ring Structure - also post Nabberu.

5.0 KEITH KILKENNY LINEAMENT (KKL)

The name Keith-Kilkenny Lineament was introduced by Gower (1976) to describe a structural zone recognised during regional mapping of the Leonora-Laverton area. Subsequent data has enabled recognition of the KKL over 500kms strike length from its exposure limits on the southern margin of the Proterozoic Glengarry basin cover at 706000N.

From this point to 6920000N, the KKL is coincident with the Perseverance Fault; Martin and Allchurch (1975); Marston and Travis (1976); Naldrett and Turner (1976); Eisenlohr (1988); Hageman (1992). The KKL consists of a deformation zone several kilometres wide mainly within ultramafic rocks. From 7060000N to 7030000N the KKL separates amphibolite facies rocks with ductile deformation from pumpellyite facies rocks with brittle faulting (east) along a talc-chlorite schist zone with major quartz blows. The ultramafic unit along the KKL can be traced for 30kms further NNW under Proterozoic cover. Strike-slip displacement along the Perseverance Fault is sinistral; Hageman (1992); Eisenlohr (1989).

Along this sector the KKL is here interpreted to be the boundary between the Southern Cross Province (west) and the Eastern Goldfields Province. Metamorphic grade, deformation style and lithological associations west of the KKL are very similar to those found in the eastern part of Southern Cross Province.

Between 7040000N and 7030000N the KKL intersects a series of north-south trending dextral fault zones which in their northern extensions control mineralisation in the Wiluna Field - the Wiluna strike slip Fault system; Hageman et al (1992). The system branches from the KKL at a 20° anticlockwise bend.

South of 703000N the KKL is a major ductile deformation zone separating a sediment sequence (west) and a felsic-mafic-ultramafic volcanic sequence (which hosts significant nickel mineralisation). This shear zone can be traced using aeromagnetics, and drilling in areas of poor exposure, south to 6965000N, separating the sediment (including conglomerates) to the west and volcanic sequences. At this point the greenstone belt (6965000N) "necks" and swings from a north-northwest to a north-south orientation; and within a sector of complex north-west to north-south faults the KKL "steps" to the eastern greenstone- granite contact, south of 6950000N. Gold mineralisation is commonly associated with NW faults in this sector; Eisenlohr (1989). In this sector the KKL merges with a dextral; Eisenlohr (1989), Platt et al (1978); shear zone, which forms the western margin of the Agnew Greenstone Belt. (Waroonga Fault)

Between 6950000N and 6910000N, the KKL is coincident with the exposed Perseverance Fault of Martin and Allchurch (1976). It is a 2km wide steep east dipping shear zone within volcanics and granitoids; sinistral reverse movements were interpreted by Eisenlohr (1989). The KKL can be traced south to 6880000N using aeromagnetic data.

East of the Wiluna-Agnew Greenstone Belt, aeromagnetics and gravity show that the granitoids consist of elongate coherent sheets or lenses, contrasting strongly with the chain of ovoid granitoid (post tectonic) intrusions along the eastern side of the Celia Lineament. (Plate 2)

South of 688000N, the southern limits of the nose of Perseverance Gneiss, the KKL separates an ultramafic dominated sequence to the west (Mt Clifford sequence of Donaldson (1982) from a mafic to felsic dominated sequence in the east. The latter is the continuation of the Yandal Greenstone belt, characteristically containing abundant felsic to intermediate volcanics. A strong gravity gradient coincides with the KKL along this sector to 683000N, reflecting this strong lithological contrast. Sinistral displacement along the KKL here is indicated by flexures in lithological contacts and in the Yandal Belt east of the KKL. Sinistral movement is also interpreted, from micro- structural data, by Williams et al (1989).

In this sector the KKL is to be regarded as a zone 5-10km wide containing numerous fault and shear zones rather than a few continuous discrete shear zones. The western margin of the zone is a sheared altered sediment unit with a conglomerate horizon along its eastern flank; Hallberg (1985); the Mount George Shear zone of Williams et al (1989). The eastern margin of the KKL south of 6845000N is a zone of fault bounded, partly sheared polymict conglomerate. This is clearly a major north-northwest fault zone as it truncates northeast lithological trends to the east, a feature readily seen on aeromagnetic images between 683000N and 677000N; the KKL here is 5-8km wide.

Structure in the Leonora district is complex. Detailed structural studies, Skwarnecki (1987); Williams et al (1989); Passchier (1994); Williams and Currie (1993); emphasise the importance of an early low angle extensional episode (D1); see also Hammond and Nisbet (1992), Williams and Whittaker (1993). A later phase of folding associated with east-west shortening re-oriented and partly reactivated these structures; Passchier, (1994). It is apparent from regional scale geometry that the eastern margin of the KKL is a relatively late complex linear fault zone with sinistral displacement, coincident with thc conglomcrate belt.

Immediately south of Leonora the KKL intersects a north-south trending structural zone, the Butcher's Flat shear zone of Williams et al (1989). This zone can be traced 80 kms south using aeromagnetics. The major Sons of Gwalia gold mine is located within a (reactivated) D1 shear zone close to the intersection of the Butchers Flat Shear Zone with the western margin of the KKL.

A cluster of small circular aeromagnetic "dipole" anomalies along the western margin of KKL (6790000N 360000E) are interpreted to be ultramafic or magnetite rich syenite plugs intruded along north-west trending faults splaying from the KKL.

South of Leonora exposures along the KKL are poor, but the structures can be traced on aeromagnetics and gravity images, and isolated subsurface data. East of Porkies Well (6770000N) the KKL is a 7km wide zone of sheared sediments; including conglomerates on the eastern margin. (Hallberg 1985). At regional scales the KKL clearly truncates the north-west trending folds to the west, the Tin Can Anticline of Stewart (1991). Locally structures are very complex and the western margin of KKL here is the locus of intense carbonate alteration, silicification and pyritization and widespread anomalous gold; Porkies Well Prospect, Stewart (1991).

From 6770000N to 6650000N the KKL can be traced on detailed aeromagnetics as a continuous 1-5km wide magnetic low zone. Where exposed, the zone is mapped by Swager (1993a) as a highly sheared sediment belt, containing siltstones; shales with local development of garnet, staurolite, and andalusite; conglomerate; and greywacke. Thin units of highly attenuated mafic units occur also. Carbonate-biotite alteration is widespread; both in the sediments and mafics adjacent to the shear zone.

Lithological layering trends, particularly east of the KKL, are slightly oblique to, and appear to be truncated by, the KKL. Where exposures are adequate it can be demonstrated that the KKL separates markedly different lithological packages; Swager (1993a) with different facing directions (to the west of KKL, units face east and vice versa).

Between 6750000N and 6720000N a suite of undeformed strongly magnetic syenites intrude mafics along the western margin of the KKL. Several of these are associated with (minor) gold mineralisation eg. Mt McAuliffe. (6738000N 397000E)

Between 6710000N and 6690000N the KKL "necks" and swings 15° clockwise. Carbonate alteration is intense (and minor gold mineralisation abundant) in this sector. Immediately east of this kink in the KKL are several 2-4km diameter stocks of quartz monzonite porphyry, associated with widespread carbonate tourmaline alteration, and gold mineralisation in the Porphyry district (Allen 1987). North-east structures partly control the location of the stocks.

The KKL is of similar character southwards until 6665000N where it swings 10-15° clockwise to an almost north-south trend and strongly transgresses lithological layering. Intense carbonate alteration and gold mineralisation occurs at the northern part of the flexure described above (6665000N Old Plough Dam) within clastic sediments within the KKL. In this sector the KKL is coincident with the Yilgani Fault of Swager (1993), separating the Kurnalpi (west) and Mulgabbie (east) "domains". The sector west of KKL has been called the Boyce Domain on geophysical grounds; Williams and Whittaker (1993), Whittaker (1993). It is about 250kms long and contains granitoids with marked magnetic zoning and unusual shapes eg. the Rabbit Ears Granite at (6652000N, 425000E, Langsford (1992). The granite dominated Boyce

Domain is clearly terminated by the KKL south of 6625000N, and this is confirmed by gravity patterns cf Whittaker (1993).

In the north-south trending sector several small alkalic syenitic plugs occur with or next to the KKL; Johnson (1991). Other small massive plugs of magnetic monzogranite occur adjacent to the KKL, where it traverses the western flank of the Yindi Monzogranite; Ahmat and Swager (1992). From 6605000N to 6585000N the KKL separates a mafic amphibolite sequence (east) from a complex faulted south plunging syncline of felsic-intermediate schists and bif. The nose of the structure is extremely complicated; see Ahmat and Swager (1992) and intruded by numerous small elongate monzogranite bodies. Here the KKL is 2km wide a zone of sheared felsic schist with "buck" quartz veins parallel to foliation.

The KKL south of 6565000N is interpreted to form the eastern boundary of a continuous linear ultramafic-mafic unit. Although outcrop is poor drilling has shown the KKL to be a steep west dipping zone 500m wide of intensely sheared and carbonate altered mafics ultramafics and sediments; Konecny (1989).

Between 6565000N and 65340000N the KKL can be traced along the eastern margin of a gravity high; the KKL separates a mafic-ultramafic sequence (west) from a sediment package to the east.

The narrow western mafic-ultramafic belt separates the KKL from a sedimentary package which is unique in the Yilgarn; Swager (1993). It contains a tightly folded greywacke and bif sequence which narrows into a conglomerate trough with complexly faulted unconformities at the western margin. The eastern boundary of the greywacke-conglomerate domain is remarkably linear over 150kms, and is coincident with a major gravity "lineament". (Yindarlgooda Fault). This is a strong contrast with the rather sinuous tracks of the KKL and the CL in same general area.

5.1 Mineralisation associated with the KKL

The KKL has been an important structural element in the development of several major gold districts. At Wiluna, mineralisation is controlled by strike faults branching from the KKL at a 20° strike change.

The Kathleen Valley - Bellevue district occurs within a complex zone of faulting where the KKL transfers from the western side to the eastern side of the Agnew Greenstone Belt.

The Leonora District occurs within a zone of complex structure where major splays from the KKL interact with (reactivated?) early low angle structures. The Porphyry District occurs close to a zone of necking and deflection in the KKL; there is extensive regional carbonate alteration. At Old Plough Dam (6673000N, 433000E) mineralisation occurs within the KKL in a deflected segment.

Numerous small gold prospects or gold anomalous carbonate alteration zones occur within the KKL or in splay faults adjacent to it, over its entire length.

5.2 Significance of the KKL

The KKL lineament has been documented as separating sectors of the Eastern Goldfields with different lithological characteristics. Most obviously these are the relative abundance of komatiite volcanics and deficiency of bifs west of the KKL compared with the east; Barley et al (1990). East of the KKL intrusive peridotites are much more abundant than komatiites. Differing styles of intermediate to felsic volcanics occur across the KKL; andesite dominated to the east, sodic dacite-rhyolite (andesite) volcanics and volcaniclastics to the west. Rhyolite dominated volcanic centers occur only to the west of the KKL; Hallberg et al, (1992)

Another significant variation across the KKL occurrence of numerous post tectonic ovoid granitoids to the east, especially in the sector between the KKL and CL; relatively few occur west of the KKL.

The variation in structural style along the KKL indicates that it is not just a belt of strike-slip faults, but includes zones of reactivated early low angle structures. Conglomerate units with granite clasts demonstrate post granite vertical movements along some strands of the KKL; the margins of the conglomerate belts are themselves shear zones, sometimes mylonitic; Hallberg

(1985). The conglomeratic clastic belt along the KKL can be traced for over 200kms. (6830000N to 6650000N).

At map scale the KKL can be seen to truncate large scale folds, and separate strongly contrasting rock packages, often with opposed facings, and as stated above, separate provinces with major lithological differences. On the half million scale compilation, and matching AGSO aeromagnetic and gravity images the KKL stands out as a sharp north-northwest "welt" across the craton.

Barley et al (1990) interpret the KKL as the suture between an "arc" assemblage (east) and a "rift" assemblage (west).

The KKL as, an entity, is clearly a craton-scale structure, penetrating to the base of the greenstone succession. It has a complex history, in part being a steepened reactiated early low angle structure (extensionsal?); Eisenlohr (1989); Passchier (1994). The most obvious mappable features of the KKL are the several strands which have been reactivated as sinistral strike-slip shear zones, or as faults with substantial vertical components marked by conglomerate belts. Such manifestations are typically hundreds of metres to a few kilometres wide, while the entire tectonic zone in the sense of Hallberg (1985) is probably 5-10km wide.

Several important late north-south shear zones/faults splay from the eastern side of the KKL. The Mertondale Fault (6913000N) is a sinistral wrench fault;

Nisbet and Williams (1990). Gold mineralisation is localised along the Mertondale Fault where strike changes.

At 68700000N the Okerbury Fault splays north from the KKL; this fault cuts through the core of Yandal Greenstone Belt, trending NNE. On the eastern side of the Yandal Belt, the fault swings parallel with the NNW trending CL. The Okerbury Fault is here interpreted to a major influence on the Yandal Belt. Significantly different packages occur of different sides; eg. there is abundant bif to the west, and voluminous andesite to the east. The fault is within a very strong parallel gravity gradient.

6.0 THE ZULEIKA SHEAR (ZS)

The ZS is a major structure traceable for 400km. Along the northern 150kms it lies close to, (or is coincident with?) the poorly documented north-south Ida Lineament. (IL) The ZS-IL is interpreted to be the western margin of the Kalgoorlie Terrain Swager et al (1992). Further south the ZS swings south-southeast and passes through the Kalgoorlie-Norseman greenstone belt, terminating at the Proterozoic tectonic front south of Norseman.

The most northerly section of the SZ is difficult to trace, partly due to poor exposure and to inherent structural complexity. Between 6800000N and 6695000N the SZ is clearly recognisable on geophysical data sets as a structural contact between granite gneiss to the east, the Riverina Gneiss of Williams (1992) and sheared greenstones to the west.

Where exposures exist the contact has been mapped by Rattenbury (1993) as the Ballard Shear (and wrongly regarded by him as identical to the Mt Ida Lineament). The ZS is a 1-2km wide steep west dipping shear zone with shallow plunging and extension lineations. It is a sinistral shear zone; Rattenbury (1993), with considerable horizontal displacement; it bounds the Kurrajong Anticline on its eastern side (6755000N).
Units within the Kurrajong Anticline can be traced on aeromagnetics and geological maps; Legge et al (1990); Rattenbury (1993). The ultramafic - dolerite-sediment package of the Kurrajong Anticline is bounded to the west by

the Bottle Creek structure, (which corresponds to the Ida Lineament's true position) separating the complex ultramafic-basalt-dolerite package from a tholeiitic basalt - bif package to the west. The position of the Ida Lineament is marked by a wide steep west dipping, zone of sericite schist with zones of carbonate-biotite alteration.

The Kalgoorlie-Barlee Terrain boundary therefore is west of the western flank of the Kurrajong Anticline. The terrain boundary (IL) then follows the arcuate (concave east) western boundary of the Riverina Gneiss north of 6800000N (Plate 3). It then links with the interpreted terrain boundary at approximately 7025000N, 227000E (Plate 2).

This interpretation allows inclusion of all the Riverina Gneiss complex within the Kalgoorlie Terrain. Gravity confirms this; the gneiss complex, central granitoids and pattern discontinuities at the terrain boundary are recognisable even though the gravity data points are widespaced. (11kms)

North of 6800000N the ZS is difficult to define; it swings slightly anticlockwise into the core of the Riverina Gneiss "Dome" which contains numerous late ovoid granitoids. Strong north-east aeromagnetic trends cut this zone and offset gneissic layering. (Plate 3). The ZS may link with the Waroonga Shear along the western margin of the Agnew Belt as suggested by Eisenlohr et al (1993) fig 1, although this is clearly a dextral shear structure. There is insufficient evidence for such a linking. The ZS may terminate to the north in low angle structures within the flanks of the Riverina Gneiss Dome.

Further south, between 6755000N and 6650000N the boundary between the Southern Cross Province and Eastern Goldfield Province (equivalent to the boundary between the Kalgoorlie Terrain and Barlee Terrain; Swager et al (1992) can be placed along the western edge of the narrow sectors of the greenstone belt (6755000N to 6725000N). Southwards the boundary is within greenstone, but can be drawn on the basis of different lithologic packages mafic and bif to the west and mafic and ultramafic and sediment to the east. There is also a strongly contrasting gravity expression (marked highs to the west). Between 6687000N and 6680000N the boundary wraps around the eastern margin of an elongate granitoid which is cut by northeast dextral faults. Linear structures of this orientation are a common feature of the Barlee Terrain. This indicates dextral movement along the boundary which is the Mt Ida Lineament.

South of 6650000N the western greenstone sequence (Barlee Terrain) cuts out against granite-gneiss terrain; the Mt Ida Lineament continues south.

Between 6695000N and 6655000N the ZS courses essentially north-south at the sheared contact of greenstones and a complex of nested granitoids; Siberia granites of Witt and Swager (1989). The ZS over-prints the contact zones of the granitoids and shows subhorizontal lineations within a foliated zone 1-3kms wide. Quartz veins pegmatites and porphyries are abundant within the contact zone. The shear zone is vertical to steep west dipping.

South of 6650000N the ZS bends sharply anticlockwise to trend southeast. The ZS is largely confined to a strongly sheared carbonate altered ultramafic (komatiite) unit; the structure truncates successively younger units of the Ora Banda sequence southwards eventually paralleling the western limb of the Kurrawong syncline.

A major flexure in the Ora Banda sequence indicates dextral movement along the ZS in this sector (6630000N).

Between 6650000N and 6615000N (Blue Funnel Mine) the ZS is a 1-2km wide zone of intensely foliated carbonated and variably quartz veined ultramafics, dolerite-basalt, sediments and porphyry. At Blue Funnel the ZS is in contact with the Kurrawong Beds (ie has transgressed the entire Ora Banda sequence). Much of the ZS is talc-chlorite schist. More competent dolerite and porphyry units are boundinaged and cut by late brittle faults. Both sinistral and dextral (late) displacements are indicated. The ZS is near vertical with both easterly and westerly dips 80-85° varying along strike and down dip. There is no tendency to flatten with depth in deepest drilling along the shear (>400m VD).

As well as transgressing layering at regional scales and local scales (where seen in open pits such as Zuleika and Kundana) the ZS separates two synclinal sectors with opposed plunge senses and different lithological packages although both are broadly speaking "Black Flag Beds". The western syncline contains doleritic units which do not occur in the eastern syncline. Units within the ZS are somewhat unusual, including "fragmental" textured ultramafics, which are unlike any units in the adjacent packages (Mal Dickie pers. comm.)

Several zones of gold mineralisation are known along this sector of the shear; Zuleika, Broads Dam and Blue Funnel; in each case gold mineralisation is associated with strong carbonate-biotite alteration and high levels of arsenic.

South of Blue Funnel (6615000N) the ZS contains little ultramafic material, but consists of a steeply west dipping shear zone with carbonated dolerite, black shales and feldspar porphyritic basalt ("cat rock"). The shear zone is slightly west of the Kurrawang Beds basal unconformity and the "footwall" of the shear at Kundana (6602000N) is strongly carbonated andesite (basalt?) and sediment. The intensely sheared carbonated zone is more than 500m wide. South of Kundana outcrop is non existent in a major salina but magnetics show the ZS trends 325°, transgressing lithological layering west of the fault at 350°. Wide steep west dipping shear zones are exposed in road cuttings at the western Kurrawang Beds contact in the interpreted ZS position at 6586000N.

Between 6586000N and 6550000N the ZS is not exposed but has been traced by shallow drilling Sheddon (1991) as a zone of intense foliation and carbonate alteration in felsic volcaniclastics. Minor amounts of chlorite schist also occurs in the shear. Here the ZS is parallel to and immediately east of an ultramafic unit and strands of the ZS occur along the contact. A noteable feature of the

ZS is its tendency to occur within or close to ultramafic units as does the Boulder-Lefroy Fault; Langsford (1989).

A small plug of syenite with an intense radiometric expression occurs immediately east of the ZS at 6572000N 351000E.. Minor gold mineralisation occurs within the ZS at 6571000N (Mark Miller pers comm.) within zones of locally strong carbonate alteration.

At about 6550000N the ZS separates the major north-south Abattoir mafic-ultramafic belt to the east from the north-northwest striking units west of the shear. South to 6542000N the ZS has been traced by drilling as a 200-500m wide belt of talc-carbonate-chlorite schist and silicified sheared shale. Slivers of dolerite and basalt occur within the shear, which separates ultramafic to the east from a high magnesian basalt-shale unit to the west, which may be a fault repeat of the Cave Rocks sequence about 1km to the east; Langsford (1987).

Between 6542000N and 6540000N the ZS wraps around a lens of altered porphyritic rhyolite, the shear zone is wider on the western side. The mafic-ultramafic units adjacent to the porphyry are altered to carbonate-sericite-fuschite schists and porphyry is intensely sericitised, carbonated and pyritic. Gold mineralisation with a strong As-Sb-Ag-Hg-W association occurs where the ZS swings into contact with the porphyry. Contacts dip steeply west; the sheared altered zone is >200m wide at the Green Leader Prospect; Langsford (1988). The mineralogical association here is unusual; including bertherite (Fe Sb_2S_4), stibnite, and native antimony Langsford (1988).

At 6535000N the ZS swings north-south (a clockwise bend of 15-20°) and cuts through a complex shallow northwest plunging synform in the Pilbaily Hill area; Langsford (1987), Griffin (1990). The gabbro slices within the synform appear to be several stacked thrust sheets overlying north-south trending sediments; the underlying sediments have a different fold style; Griffin (1990). Relationships between the ZS and the low angle structures are not clear; possibly some strike slip movement along the ZS has been taken up along low angle structures as along the Boulder-Lefroy Fault; Langsford (1989). In this sector the fault is a zone of strong foliation and carbonate alteration up to 200m wide; Langsford (1987).

South of Pilbailey Hill to 6505000N the ZS traverses mainly felsic volcanics and volcaniclastics (Black Flag Beds) which are poorly exposed and have little magnetic character. The structure can be traced however by the truncations of arcuate layering trends west of the fault; they are visible on enhanced images of detailed aeromagnetic data. The ZS itself is marked by a chain of weak linear aeromagnetic features which are interpreted to be sheared and altered mafic slices; Langsford (1987). The ZS in this sector corresponds to the Black Knob Fault of Griffin, (1990).

Gravity and seismic work has confirmed the presence of a major structure, in the inferred ZS position, at 6510000N; Trench et al (1993). The ZS is interpreted as a moderately to steeply west dipping branching upward structure, merging with a major detachment at 6kms vertical depth. Trench et al (1993) interpret a thicker sequence of Black Flag Beds east of the ZS, and also an easterly thickening of the "basal" felsic sequence from 1 to 3kms. This is a very similar model to that of the ZS at 6620000N suggested by Drummond et al (1993) the only significant difference being an interpreted east dip.

At 6506000N the ZS intersects a major mafic-ultramafic belt extending south from Higginsville. Several important north-south structures splay from the western side of the fault and control gold mineralisation at the Higginsville mining centre.

South of Higginsville the ZS splits into divergent strands; the continuation of ZS passing to the east of the Norseman Domain, and Mission Fault to the west; Swager et al (1990). The ZS and Mission Fault terminate at the Proterozoic Fraser Range tectonic front. This overprint at 1100-1300Ma; Meyers (1990) being much later than the latest movement on the LSZ has obliterated their original tectonic terminations.

6.1 Mineralisation associated with the ZS

Many centres of gold mineralisation occur within or close to the ZS. Copperhead district (6772000N) is located at the granite "nose" of the Copperhead Anticline where the Ida Lineament diverges from close parallelism from the ZS. In the Davyhurst district (6660000N) gold mineralisation occurs within the Ida Lineament and ZS as 20-30° N plunging pods associated with intense silica-biotite carbonate alteration.

At Hawkins Find 6625000N, Zuleika 6621000N, Broads Dam 6618000N, and Blue Funnel 6615000N, mineralisation occurs in strongly carbonated porphyry, mafic and ultramafic units within the ZS, as steeply plunging pods, which are often boudins of brittle units within ultramafic schist.

At Kundana (6602000N) mineralisation occurs in mafics and silicified black shale units within a wide carbonate alteration zone.

At Zuleika North, Steinway and St Helens (6571000N) gold occurs within carbonate altered felsic volcaniclastics. (M. Miller pers. comm.) within the ZS.

At Green Leader (6542000N) hosts are sericitized carbonated porphyry and fuschitic carbonated ultramafic at a deflection around a porphyry body.

At Higginsville, major mineralisation consists of quartz vein arrays hosted in east dipping quartz gabbro units. The gabbros were intruded along contacts between basalts and sediments, or ultramafics and basalts, and are adjacent to major splays south from the ZS.

The common theme of mineralisation along the ZS is strong arsenic-tungsten association. This contrasts strongly with mineralisation along other structures (eg. BLF) where the same elemental association is present (As-W-Sb) but As-W levels are several orders of magnitude lower. Consistent high arsenic-tungsten levels indicate a common fluid source for mineralisation along the ZS and a source different for mineralisation along other structures, even those quite near; the BLF is only 12 kms east of the southern sector of the ZS.

Over much of its length the ZS is within or adjacent to belts of sheared, strongly carbonate altered ultramafics after komatiites. This is interpreted to reflect the general propensity for such structures to focus into readily sheared, incompetent units; and more fundamentally, reflect the deep crustal association of such major long lived structures.

Isotopic studies of the “regional” carbonate alteration associated with major structures (and particularly within ultramafics) shows a mantle origin for such carbonates; Golding et al (1987).

Over most of its length, both in the north-south segment (between 6820000N and 6650000N) and the north-northwest segment, the ZS is relatively straight with few mappable beds or structural complications. This is particularly noticeable in segment between 66040000N and 6590000N; large alteration systems occur, but host only small, poddy mineralisation. The largest, Kundana, occurs close to a distinct, although small, clockwise deflection. A large poorly tested alteration system (Green Leader) with an unusually strong As-Sb-Ag-Hg association occur where the ZS is locally wrapping around a competent porphyry body.

The largest known gold mineralised system related to the ZS, at Higginsville, occurs where the ZS swings noticeably clockwise and numerous splay faults occur as the ZS transects a major mafic belt.

6.2 Significance of the ZS

The ZS is the mappable expression of a long-lived crustal scale structure traceable for 400kms (Plate 3). An origin as an early extensioned feature is indicated by its termination, to the north, in the core of the Riverina Gneiss Dome interpreted as a extensional metamorphic core complex; Williams (1993). It is also close and parallel to, the Ida Lineament, over 100kms of strike. The Ida Fault is interpreted from seismic data as a major east dipping reactivated extensional structure; Drummond and Golbey (1993).

As a late structure it is exemplified by shearing and alteration of Kurrawong Beds (the youngest Archaean sedimentary units) and sinistral displacement of late granitoids by related splay faults.

Unlike the KKL and CL, the ZL has almost no late alkalic or syenitic intrusions associated with it.

Two seismic and detailed gravity traverses across the ZS; Drummond (1993) Trench et al (1993); show the ZS to be a major structure, penetrating the greenstone sequence and merging with a sole structure separating the greenstones and the lower felsic sequence. The geophysical data confirm that the ZS separates different domains; the southern traverse (6510000N) shows marked thickening of the felsic Black Flag Beds, and the (unexposed) lower felsic unit, east of the ZS.

A general "east block down" trend along the NNW trending portion of the ZS is suggested by the following. Firstly the presence of the Kurrawong Beds, a clastic filled trough, east of the fault. The clastic fill was derived from west of the ZS. Secondly, general thickening of the felsic volaniclastic supracrustal sequence east of the fault. Thirdly, west of the ZS, metamorphic grades are low to mid-amphibolite; to the east, lower amphibolite to upper greenschist; Knight (1993).

The ZS is considered a domain boundary, Swager et al (1990) separating the Kalgoorlie Domain to the east and Coolgardie Domain to the west. There is not the major variation in lithological packages across the ZS as there is across the KKL. In this aspect the ZS is more like the Boulder Lefroy Fault; Langsford (1989).

Like the other LSZ described here, the ZS is not fundamentally a transcurrent fault zone, although its present incarnation has some such attributes; lithological dislocations, sinistral movement indicators etc. As suggested by geophysical modelling; Trench et al (1993,) Golbey et al (1993); the ZS is a complex upward flowering structure, resulting from reactivation during the major shortening phase; Williams (1993); Swager et al (1992), Hammond and Nisbet, (1992). The sinistral strike-slip component is a late event, with movement exploiting one of the strands of the structure to produce a continuous shear zone.

7.0 EDALE TECTONIC ZONE (ETZ)

The Edale Fault was first described by Stewart et al (1983) as a structure along the eastern side of the Sandstone Greenstone Belt; Eisenlohr et al (1993) included the Edale Fault within their Edale Tectonic zone which was described as a "complex assemblage of gneiss and shear zones". These workers described in detail the sector of the Edale Tectonic zone between 6920000N and 6880000N.

The Edale Tectonic Zone is a major LSZ traceable over 450kms from its emergence under Proterozoic cover (7100000N). It is quite different in character from other LSZ described in this report.

The ETZ has a sigmoidal trace, rather than more or less linear as do the other LSZ. Over most of its length the ETZ traverses granite-gneiss terrain or is at granitoid greenstone contacts; other LSZ have substantial sections of their traces within greenstone belts.

Between 7100000N and 70550000N the ETZ forms the eastern boundary of the Gnaweeda Greenstone belt. A zone of talc-chlorite schists along the eastern side of the greenstone belt is interpreted to be the base of a west facing layered sill. A major north-northwest trending brittle fault marked by major quartz veins splays from the ETZ at 7065000N; this fault forms the western boundary of the greenstone belt in the southern sector. North of 7090000N the ETZ and the Gnaweeda Belt swings clockwise and trend parallel to the

Meekatharra Greenstone Belt, which defines the regional structural grain, trending north-east. This zone is the "contact" between the north-east Murchison trends and north-northwest Eastern Goldfields trends.

South of 7055000N the ETZ is marked by a narrow, and south of 7045000N, discontinuous, greenstone belt. The ETZ here separates a belt of strongly foliated granitoids with steep lineations, to the west, from massive biotite granite to the east. Foliations within the granite between the Meekatharra Belt, and the Gnaweeda Belt are mainly parallel to, but in places are oblique to, the greenstone contacts, indicating some relative transcurrent movement. Lineations within this belt of foliated granite are steeply plunging.

Biotite granite east of the ETZ is massive and has the low gravity expression characteristic of post-tectonic granitoid domains with broad domes or thick sheets of granitoid. The homogeneous moderate intensity aeromagnetic expression confirms this interpretation. This homogenous granitoid domain extends for 100kms to the granite-gneiss-greenstone domains around the Joyner's Find - Booylgoo Greenstone Belts, along an axis running 790000E.

At 7020000N the ETZ exhibits a sharp anticlockwise kink, where it is crossed by an east-west lineament zone. The east-west zone contains exposures of flat lying Proterozoic sediment, and is marked by east-west shears and quartz veining in granitoids. It also corresponds to the southern boundary of the massive granitoids east of the ETZ; and truncates and dextrally deflects the narrow Poison Hills Greenstone Belt (7020000N, 705000E). It is a Proterozoic structural feature.

South of the east-west lineament the ETZ passes along the eastern margin of the narrow Barrambie greenstone belt, which consists of a thin layered mafic sill to the west, and intensely sheared volcanics, mainly chlorite-sericite schists; Tingey (1985) to the east. Foliations dip steeply west. The belt has distinct clockwise jog at 69800000N, with associated minor gold mineralisation.

On the eastern side of the ETZ, adjacent to the Barrambie Belt, foliations in granite, layering trends and aeromagnetic linears trend more northerly than the ETZ and swing into parallelism towards it, dipping steeply east. On the western side they are parallel to the ETZ. Gravity and aeromagnetics show that the granitoids east of the ETZ are gneisses; to the west are numerous weakly deformed post tectonic ovoid granitoids. The gravity expression of the Barrambie Greenstone Belt is anomalously high when compared with similar sized belts in the same province eg. Joyner's Find Belt, indicating that the former has considerable depth extension. The ETZ, bound to this greenstone unit, would also be a deep structure.

At 6930000N the greenstone belt terminates and the ETZ again swings clockwise, intersecting a strong north-northeast linear zone of strongly gneissic granitoids, and a major dextral shear zone the Younami Fault; Libby et al (1993). The dextral kink in the ETZ is consistent with interaction with a dextral shear.

South from 6920000N the ETZ is coincident with the Coomb Bore Shear zone of Libby et al 1993. The ETZ along this sector to 6880000N is a 1-3km wide zone of foliation with several 10m wide mylonite zones. Movement is sinistral with a major strike component; Eisenlohr et al (1993). This sector is entirely within gneiss.

Between 6880000N and 6820000N the ETZ passes along the western side of a poorly exposed highly attenuated narrow greenstone belt. (Cook Well Greenstones). A narrow belt of intensely sheared metasediments (Maynard Hills Greenstones) occurs 3-5km east of the ETZ with a gneiss belt between them; the White Cloud Gneiss of Stewart et al (1983). Foliation in the greenstone belts dip west; in the gneiss slice, foliation dips east. The thin greenstone belts and gneiss between them are interpreted to be a major structural zone separating two granitoid domains. To the east, aeromagnetic expression is low intensity, and quite homogenous with trends subparallel to the ETZ. Several large mainly massive ovoid granitoids occur eg. 6865000N to 68900000N. West of the ETZ magnetic levels are higher, much more irregular and linear trends are at high angles to the ETZ. Gravity expression to the west of the ETZ is relatively high, indicative of gneissic terrains; cf. Whittaker (1993).

At 6825000N the ETZ intersected by a north-northeast trending ductile dextral shear zone, the Victory Bore shear zone of Eisenlohr et al (1993).

There is a dextral flexure in the ETZ at this point. The Victor Bore shear is a major quartz reef zone with ultramafic slices within it, steeply west dipping.

From 6815000N the ETZ cuts through the Brooking Hills Greenstone Belt, splitting into two parallel faults. The most easterly swings to about 350° and separates a bif-mafic package (east) from a mafic-ultramafic package including some dismembered layered mafic sills; the westerly fault separates the central package from a basalt dominated sequence to the west.

The ETZ continues through the central part of the Brooking Hills Belt, swinging southerly to parallel the Mt Ida Lineament 35 kilometres to the east. The interpreted extension of the ETZ appears to truncate and deflect the southeast terminations of greenstone belts at 6630000N and 6575000N.

7.1 Significance of ETZ

The ETZ differs from LSZ in the Eastern Goldfields Province. It mainly traverses terrain dominated by granite gneiss or post tectonic granite and it separates different granitoid terrains, rather than different greenstones. Available geological data are insufficient to differentiate granitoid terrains, and to recognise their boundaries, especially under cover. Enhanced images of ASGO aeromagnetic and gravity data make feasible regional scale recognition of substantially different granitoid terrains. Gneiss dominated terrains have relatively high gravity and aeromagnetic signatures with well developed magnetic character. "Post tectonic" granitoids on regional scales have low gravity signatures and low, even diffuse aeromagnetics.

Layered mafic intrusions occur only within or southwest of the ETZ; layered intrusives of all scales are a feature of the Murchison and Southern Cross Provinces elsewhere.

The ETZ marks the northern limit of the northeast geological trends characteristic of the Murchison and Southern Cross Provinces; northeast dextral shears interact with and displace the ETZ in several places.

The ETZ has similarities with reactivated low angle early extension structures (lags) described by Hammond and Nisbet, (1992). The similarities are; the association with thick layers of strongly foliated granitoids, with steep extension lineations; narrow, highly foliated and lineated greenstone belts with anomalously high metamorphic grades (amphibolite facies); occurrence of synkinematic granite sheets along the structural zone; and the occurrence within greenstones granitoids and gneisses, of thin banded "ferruginous cherts" and magnetite rich units, similar to those described by Hammond and Nisbet 1993. Reactivation during crustal shortening and later strike slip movement has produced the complex array of structures that now form the ETZ.

Along part of its length 7100000N to 70200000N the ETZ forms the logical eastern boundary to northern part of the Murchison Province, previously ill defined; Meyers (1990). On the basis of the geological differences discussed above, the ETZ has greater claim as a Terrain Boundary than some well entrenched in the literature; see Swager (1993); Meyers (1990).

7.2 Proterozoic Influences on the ETZ

A zone of linears trending 315° of inferred Proterozoic age cuts across the Archaean supracrustals south of the Glengarry Basin. The linears are visible on enhanced aeromagnetic images and correspond to a swarm of quartz veins in granitoids. To the west the linears are cut off the Yalgar Fault (7115000N, 679000E); and "refracted" across the granitoid slice between the Meekatharra and Gnaweeda Belts (7085000N, 670000E) suggestive of late sinistral movement. South east the bundle of linears diverges slightly and fades out at about 8000000E. At 7070000N 770000E the 315° linears intersect an east-west trend marked by a shallow graben of Proterozoic sediments, and faults filled by quartz veins and dolerite dykes. The linear swings into parallelism with the 315° trend and hosts a major calcrete uranium deposit at Yeeliree. (6990000N, 787000E) Such features are here interpreted to be the weak "front" of the extensional tectonic regime responsible for Glengarry Basin formation.

8.0 THE MEEKATHARRA-MT MAGNET GREENSTONE BELT

Three major LSZ can be recognised within the Meekatharra-Mt Magnet Greenstone Belt; (Plate 1) the Meekatharra East Shear (MES); the Magnet-Meekatharra Shear (MMS) and the Cuddingwarra Fault (CF). The two latter structures have been rather loosely described by Watkins and Hickman (1990,) and Eisenlohr et al (1993). A fourth, the Big Bell Fault (BBF) occurs further west.

Identification of the LSZ described here owes much to the geological mapping of Hallberg (1990; 1991a, b; 1992; 1993).

North of 7105000N the greenstone belt is unconformably overlain by Proterozoic Glengarry Basin clastics. From 7105000N to 707000N the Meekatharra Greenstone Belt consists of komatiites with basalts and bifs. Aeromagnetics and drilling show that the margins of the belt are highly sheared; the MMS traverses the steep east dipping western contact, the MES the eastern. This sector corresponds with a belt of west-northwest Proterozoic dyke trends in the granitoids external to the greenstones.

The trend of greenstone layering visible on detailed aeromagnetics indicates dextral movement across the greenstone belt. Magnetic units are strongly attenuated along the eastern side of belt, the MES, indicating a focus of shearing along this structure.

From 7080000N the MMS separates the Meekatharra Greenstones from a strongly banded gneiss, which has a characteristic linear aeromagnetic signature and intense potassic radiometric signature. The western margin of the gneiss is separated from a greenstone belt further west by the CF which merges with the MMS at 7080000N. The gneiss is interpreted to be a slice tectonically emplaced along a major structural zone.

At 7060000N the MMS diverges from the north east trending greenstone contact; and swings clockwise. The major Meekatharra mining district occurs at this strike change which, in detail, is a structurally complex area. Watkins and Hickman, (1990); Hallberg (1991).

At map scale the MMS forms the western boundary of the core of the Meekatharra Belt, the Polelle Syncline, which contains a complete sequence of the Meekatharra greenstones. The syncline west of MMS contains only the lower part of the sequence; Hallberg (1990, 1993). Gravity patterns confirm this; the mapped MMS closely matches the steep gradient along the gravity high to the east.

To the east Polelle Syncline is bounded by the MES; the syncline is notable its complete and coherent sequences; Hallberg (1990) and almost complete lack of ovoid post tectonic granitoids. The latter are abundant in the greenstones west of the MMS. (Plate 1).

Where exposed the MMS in the greenstone belt is a zone of ductile deformation up to 500 metres wide, particularly well developed in ultramafics. It consists of anastomosing mylonitic shear zones with intervening lenses of weakly to undeformed rock. Reactivation is common, shown by faults and brittle-ductile zones overprinting mylonites. The later deformation is associated with alteration and gold mineralisation; Grigson et al (1990): Wang et al (1993). The MMS and MES converge at 7000000N where the Polelle syncline pinches out; the structures can be traced across the granitoids as a 1 kilometre wide magnetic low, to link with mapped shear zones in the Tuckabianna Greenstone Belt. In this sector 7000000N to 69750000N the MMS separates west dipping foliated granodiorite and gneiss (Hallberg 1991) to the east, from ovoid post-tectonic granodiorite tonalite bodies to the west; Suite II of Wang et al (1993).

The Reedy's shear, west of the MMS-MES convergence is linked (9852000N, 624000E) to the major regional shears by a northeast trending fault or shear. Exposure is poor in this area and the linking structure can only be traced on detailed aeromagnetics. The Reedy's Shear is a linear vertical shear zone up to 400m wide. Gold mineralisation is related to reactivation of the brittle-ductile deformation zone during granitoid intrusion; Grigson et al (1990); Wang et al, (1993).

South of 6975000N the MMS and MES diverge and form boundaries (west and east) of the Tuckabianna Greenstone Belt. As in the Meekatharra belt to the NE. the sector between the MMS and MES is a syncline (Kurrajong Syncline) containing a coherent sequence. On lithological grounds the sequences in the Kurrajong Syncline can be "correlated" with lower and middle sections of the Polelle Syncline sequence; Hallberg (1991). West of the MMS is a greenstone sequence much more deformed and metamorphosed than that to the east. The MMS is a poorly exposed ductile shear zone mostly within andesitic units, with intense carbonate alteration and minor gold mineralisation. While the MES shear is parallel to greenstone layering, the MMS is oblique to, and truncates layering.

The MES forms a remarkably linear granite-greenstone contact, a strongly lineated and rodded amphibolite grade zone south of 6912000N.

Although the MMS and MES vary somewhat in character along strike, they are related in that they form the structural boundaries of a syncline which contains a coherent sequence traceable for 180 kms. The package is the lowest stratigraphic sequence in the Murchison Province; Hallberg (1993). Like other packages inferred to be towards the base of greenstone sequences, as in the Norseman-Wiluna Belt, the Meekatharra sequence contains abundant komatiites.

The fault bounded belt is interpreted to be the expression of a volcanic filled rift zone; it also separates sectors with markedly different geology. There are very few post tectonic ovoid granitoids east of the former rift corridor.

South of 69500000N the MMS separates the Tuckabianna greenstone sequence from a strongly foliated to gneissic monzogranite; Hallberg (1993) with an intense radiometric signature. The geophysical expression and structural position are identical to that of the gneissic slice west of Meekatharra. Contacts are intensely sheared.

At 6927000N the contact, and the foliated granite slice swing sharply anticlockwise (030° to 160°). The inflection on the western contact of the granitoid is the north-south trending Cuddingwarra Fault (CF).

To the south the eastern greenstone narrows dramatically to a thin screen within foliated granite; the latter is continuous with the extensive belt of foliated strongly radiometric granite to the south east. The Tuckabianna-Meekatharra Belt is thus separated from the Mt Magnet Belt by a structurally emplaced slice of granitoid. Within, and north east of the bend layering and foliation are parallel, dipping steeply north-west, in both granitoids and greenstone belts on either side. South east of the bend foliation and layering dips south-east.

North-northeast trending aeromagnetic breaks cut across the granitoid in the nose of the flexure; the strongest of these are strike extensions of the MMS and MES; the latter shows small dextral offsets in bif and post tectonic granitoid at 6903000N 588000E. These extensions terminate against the CF.

South of the CF the 030° trend continues strongly; although individual structures can't be matched across the CF, the dextral 030° trending Golden Stream and New Chum Faults; Thompson et al (1990) are almost "along strike" projections of the MES. This structure (interpreted as the MES) can be traced, with consistent dextral offsets through the Mt Magnet Greenstone Belt and for 70 kms south-southwest through granite-gneiss terrain. Within the granitoid-gneiss, the MES is a linear zone marked by massive quartz blows and reefs up to 20m wide, which correspond to aeromagnetic lows. South-west of the Mt Magnet Greenstone Belt several quartz-filled brittle fault zones splay from the MES, with more southerly trends. A complex gneissic dome is located between the MES and the CF to the east.

The extension of the MES south-south west across the Mt Magnet Greenstone Belt and the CF, is a late brittle dextral fault system with minor strike slip displacement. It offsets the CF dextrally. Unlike most LSZ it can be traced for a long distance into granitoid terrain.

At the Mt Magnet Mining District mineralisation is controlled by "Boogardie Breaks" which are 030°-040° faults with minor dextral strike-slip displacements, virtually parallel to the MES.

8.1 Significance of the MES-MMS

At map scale the MES and MMS together form a linear corridor readily traceable for 300kms, trending 030°. The MES and MMS within this corridor have variable character; late brittle ductile strike slip faults; reactivated lags; broad anastomosing ductile shears with carbonate alteration; and structures with considerable vertical movements. Over much of their length the structures bound synclinal sectors with coherent lithological packages containing the "basal" Murchison sequence; Hallberg (1993).

The LSZ, northeast of the major flexure at 6920000N, also separates significantly different geological sectors; to the west is relatively coherent "upper" Murchison greenstone sequences; Hallberg (1990, 1993) intruded by numerous ovoid post tectonic granitoids. (2640 Ma; post folding suite I of Watkins and Hickman (1990); suite II of Wang et al (1993). To the east are foliated granitoids (2670-2680 Ma; recrystallised monzogranite of Watkins and Hickman 1990; Suite I of Wang et al; (1993). Greenstones east of the LSZ are of uncertain "stratigraphic" affinity dissimilar to greenstones west of the LSZ; Hallberg (1990).

Gravity patterns reflect this major difference in crustal architecture difference across the MES. To the east are broad deep lows characterising "external" granitoids with large scale domal granites; to the west are high frequency, tightly curved pattersn reflecting greenstones and smaller ovoid granitoids.

West of Mt Magnet the MES can be traced 100kms across granite-gneiss terrain as an 030° break in gravity patterns.

The corridor defined by the MMS and MES is a crustal scale structure which has been repeatedly reactivated; the latest movement being brittle dextral faulting.

8.2 Mineralisation associated with the MES-MMS

Several gold centres are directly related to the MMS and MMR. At Meekatharra, the main mineralisation occurs across a complex structural zone where the MMS diverges from the greenstone-gneiss contact and transgresses greenstone stratigraphy. At Reedy's, gold mineralisation occur along a reactivated ductile shear zone linked to the MMS at the convergence of the MMS and MES. At Tuckabianna mineralisation occurs within altered andesite with the MMS and where bif is intersected by splay faults from the MMS.

At Mt Magnet a major gold district is partly controlled by 030° structures parallel to the MES and within the south-south west projection of the MMS-MES corridor. This district is also immediately west of the intersection of the CF with the MMS-MES corridor.

9.0 THE CUDINGWARRA FAULT (CF)

Between 7085000N and 7040000N the CF forms the steeply dipping structural contact between granitoid gneiss to the east and the Abbotts Greenstone Belt to the west. The flexure of lithological layering in the greenstones to the west of the CF indicates dextral movement. South of 7040000N the CF is marked by a belt of graphitic schist up to 1km wide; Hallberg (1992). The schist unit truncates magnetic markers (layered sills) in the mafic unit to the east, which strike more easterly than the CF. West of the CF is a belt of strongly sheared felsic volcanics and volcaniclastics, and basalts; east of the CF are basalts and dolerites/gabbros; Hallberg (1992). In this sector (7040000N to 7000000N) the CF is the eastern margin of a deformation zone 2-3km wide, and separates the Meekatharra Belt from the Abbotts Belt.

At 7000000N the CF bends into a more southerly trend; marked as before by a 200-500m wide band of graphitic schist, and sheared greywacke; Hallberg (1992). The CF truncates mapped units and lithological layering trends visible on aeromagnetics; and separates different rock packages to the east and west. Units west of the CF face east, and vice versa. South of 6955000N the CF truncates the Day Dawn Dolerite, and southwards to 6920000N successively truncates older units of northwest dipping and younging stratigraphy in the Cue district.

The CF can be traced east of the Mt Magnet mining centre, passing through the Lennonville mining district. The main trace of CF is marked by a 100-200m wide coarse sandstone unit, to the west of a 1km wide zone of foliated mafics and ultramafics. There is a slight anticlockwise deflection of the CF immediately east of the Mt Magnet mining centre.

South of Mt Magnet (6890000N) the CF trends north-south and forms the eastern boundary of several small greenstone belts on the east flank of a granitoid-gneiss dome. Aeromagnetics indicate that the greenstones are continuous but thin. Gravity shows that the CF is the boundary between gneiss dominated granitoid terrain (west) and massive granitoids (east).

9.1 Significance of the CF

The CF is a continuous corridor 400m to 1km wide, of highly foliated graphitic shale, siltstone and greywacke. Lithological layering on either side of the CF is generally truncated at angles of up to 30^{O}; and the structure separates different lithological packages, often with opposed facings, over most of its length.

Between 7015000N and 6984000N the highly sheared sediments and felsic volcanics within the CF are intensely carbonate altered. The alteration (carbonate-chlorite-pyrite) extends for several kilometres laterally into mafic volcanics west of the CF; Hallberg (1991). This zone of intense alteration corresponds to the marked clockwise bend.

The northeast trending sector of the CF forms the western boundary of the zone of abundant ovoid post-tectonic plutons. Over its length it forms the eastern boundary of a complex anticlinal zone; the north-south trending sector is the Big Bell Anticline (7000000N to 6920000N). Although not as spectacular at map scale as the MMS - MES corridor, the CF is clearly a major structure.

9.2 Mineralisation associated with the CF

The Cuddingwarra district (6974000N, 577000E) gold mineralisation occurs with north north-west shear zones within ultramafic units which splay from the western side of the CF; Watkins and Hickman (1990).

Minor gold mineralisation occurs within a major carbonate alteration zone along the "bend" in the CF near 7002000N, 586000E; Goldsworthy (1994).

10.0 BIG BELL FAULT (BBF)

The BBF is the most westerly LSZ in the Murchison Province. It extends 240 kms southwest from the Yalgar Fault. The southern extremity of the BBF swings into parallelism with, and may join, a major south-west-northeast trending gravity lineament cutting across the Western Gneiss Terrain (see Plate 1). In this sector of the Murchison Province, gravity and aeromagnetic patterns indicate that the BBF corresponds to the eastern margin of the transitional zone between the granite-greenstone terrains of the Yilgarn and the older Western Gneiss Terrain to the west.

The Yalgar Fault; Meyers (1990) marks the northern limit of the BBF at 7112000N. The Yalgar Fault is an east-west trending structural break between older (>3000 Mya) gneisses to the north, and "Murchison" 2700-2800 Mya granitoids (pegmatite banded gneiss of Watkins and Hickman 1990) to the south. Meyers, (1990) suggests the Yalgar Fault is late Archaean and possibly a major suture as gabbroic and ultramafic rocks occur within it. The Yalgar Fault has been reactivated during Proterozoic southward directed thrusting. This movement along the Yalgar Fault post dated early Proterozoic dolerite dyking, as disrupted elements of the dykes occur within the zone of shearing which marks the fault.

The northern limit of BBF is therefore "overprinted" by a Proterozoic tectonic front, active at ≈1600 Mya.

Between 7112000N and 7080000N the BBF is arcuate, gently concave southwest. Exposure is very poor; the trace of the fault is marked by a topographic feature, the Hope River. At map scale the fault separates granitoids with dominantly east-west structural grain (marked by quartz veins and foliations) to the west, from granitoids with a north northwest structural grain, to the east. There is also a change in orientation in Proterozoic mafic dykes swarms across the BBF; west of the fault, dykes trend east-northeast; to the east dykes trend east-southeast; see Watkins and Hickman, (1990) Plate 2.

East of the BBF in this sector is a major gravity low which extends north to the Yalgar Fault. This gravity signature of strong lows occurs along the Archaean granitoid terrains immediately south of the Glengarry Basin Proterozoic structural front. (Section 12.0)

South of 7080000N the BBF bends sharply clockwise to trend south - southwest and forms the eastern margin of the Mingah Range greenstone belt between 7080000N and 7053000N. Exposures are poor but aeromagnetics indicate a zone of strong attenuation in the east limb of a regional antiform, marked by a strong linear gravity gradient zone.

Between 7053000N and 7025000N the BBF separates different granitoid terrains. To the west are a series of close packed ovoid granitoids, magnetically similar to the post tectonic suites of Watkins and Hickman (1990) and Wang et al (1993). None of these granitoids are exposed. East of the BBF is a massive intensely radiometrically active granitoid; this has been mapped as a (post tectonic) porphyritic alkalic monzogranite with abundant biotite magnetite and fluorite; Hallberg (1991), Elias (1982).

The BBF separates the alkalic monzogranite from the Weld Range gabbro-bif-basalt sequence to the west from 7043000N 7030000N. The Weld Range package is an unusual one, with distinctive aeromagnetic and gravity signatures, and has no equivalents east of the BBF. The fault here is a strongly foliated zone in mafic and granitoid, 200-500m wide, with major quartz blows within the shear.

From the Weld Range south to 7000000N the BBF separates distinctively different rock packages with different structural trends. West of the BBF are sequences of basalts, high magnesium basalts dolerites and layered sills; black shale interflow units are common; Hallberg (1991). East of the BBF is a sequence of deformed clastic sediments with minor bif. West of the BBF mapped folds have east-west trends (eg. Mulcahy Syncline, 7007000N) to north-west trends.

East of the BBF the dominant structural trends are north north-east in the clastic sediment-bif sequences.

Between 7025000N and 6990000N the trace of the BBF is a zone of no exposure. Extensive drilling between 7020000N and 7010000N; Goldsworthy (1992) has shown that the BBF is adjacent to a complex zone of aluminosilicate alteration (quartz-andalusite) and potassic metasomatism (biotite-microcline) developed in clastic sediments. Anomalous As, Mo, W and Ba occur in the alteration zone which is up to several kilometres long. A strongly potassium altered plagioclase porphyry body occurs within the BBF zone 7021000N and 7012000E; Hallberg (1992).

Several faults splay from the western side of the BBF eg. Old Prospect Zone fault at 7006000N. The splays are arcuate, concave southwest and dip steeply west. Intense carbonate alteration and minor gold mineralisation occur along them.

The sequence west of the BBF has been interpreted by Hallberg (1990) as a major east to northeast plunging syncline; this is truncated by the BBF. The BBF is marked in this sector by a major linear gravity gradient zone reflecting the structural juxtaposition of the mafic dominated package (including the Weld Range sequence) to the west, and sediment dominated sequences to the east.

South of 7000000N the BBF bounds a regional anticline (Big Bell Syncline) which plunges north-northeast. The BBF traverses the western limb of the fold, which at Big Bell (6980000N) dips steeply east, (overturned) is strongly attenuated, and metamorphosed to upper amphibolite facies; Watkins and Hickman (1990). The narrow greenstone belt and associated BBF remain near vertical to at least 1.8km. In the Big Bell area the BBF has a dextral displacement; Keele (1992).

West of the BBF is an intensely radiometrically active (K-U-Th) rare metal granitoid. There are numerous Mo, W, Be, U, Li, Sn, Ta, Nb occurrences within the monzogranite, which contains abundant pegmatites and quartz veins. Granitoid east of the BBF, forming the core of the Big Bell syncline, is petrographically similar; Hallberg (1992) but is much less radiometrically active (K dominated) and contains no rare metal occurrences. Further south and east of the BBF (6975000N) the granitoid contains trains of xenoliths of bif which become more common and coherent to the south.

From 6975000N the granitoid east of the BBF is dominated by gneissic varieties. Substantial amounts of bif and amphibolite within the gneiss give it a characteristic aeromagnetic expression; the gravity signature is also that of a gneiss belt. Trends are north-south.

West of the BBF is a complex granitoid terrain, with elements of gneiss and post-tectonic granitoids; suite II syenogranites of Watkins and Hickman (1990). This sector of the BBF is within the eastern part of the transitional zone between the Western Gneiss Terrain and the Murchison Province; this is clearly shown by the elevated gravity values and change in gravity patterns.

South of 6950000N the BBF splits and the several branches traverse the Dalgaranga greenstone belt. A major strand, the most northerly, separates upper amphibolite to granulite grade metasediments and mafics (north) from greenschist grade layered sills and felsic volcaniclastics to the south. A second major strand separates the latter sequence from a mafic volcanic - dolerite - gabbro dominated sequence to the south.

The BBF passes along the north west flank of the major gravity gradient defining the mafic "core' of the Dalgaranga greenstone Belt. It also separates the northeast trending Dalgaranga Belt from the north-south trending Warda Warren Belt which unlike Dalgaranga contains abundant bif.

West of the Dalgaranga greenstone belt the strands of the BBF are parallel to, and probably part of, a major northeast trending linear gravity/magnetic feature which dextrally offsets the WGT - Murchison Province Boundary by about 100 kms (Plate 1).

10.1 Significance of the BBF

Like other LSZ in the Yilgarn, the BBF is a complex zone from several hundred metres to several kilometres wide which separates domains of distinctly different geology. The major differences between the domains are in direction of structural grain, composition of volcano-sedimentary packages, and granitoid type. There is only limited detailed structural information about the nature of the BBF; where examined in detail it is a zone of anastomosing mylonitic zones, steeply dipping with steep extension lineations, with strong hydrothermal alteration.

The central part of the BBF is associated with intensely radiometrically active granitoids (U-Th-K) with abundant minor rare metal mineralisation (Mo-W-Sn-Ta-Nb-Li-Be) west of the BBF from 6990000N to 6930000N. This association occurs within the transition zone between the WGT and the Murchison Province. Similar associations of major gold deposits with K rich, rare metal granitoids adjacent to crustal scale structures have been reported at Val D'or - Cadillac; Hodgson (1992) and Hemlo; Smythe et al (1986).

Between 7023000N and 7000000N the BBF is not exposed but separates a deformed mafic sequence (west) from a clastic sediment-bif package. The clastic units within this package are of local provenance indicating deposition in a local trough related to tectonism along the BBF immediately to the west; Hallberg (1992); Julian Goldsworthy, pers. comm. Linear, structurally controlled quartz-and andalusite alterations zones have been located by drilling immediately east of the BBF, associated with wide zones of potassic altered sediments and an extensive (12km x 2km) potassic altered plagioclase porphyry; Hallberg (1992). The overall zone of alteration extends about 15kms along the eastern side of the BBF and is 2-5 kms wide.

While almost nothing is known about the detailed structure of the BBF (owing to poor exposure) the fundamental nature of the zone is shown by its separation of different geological domains, and its association with distinct suites of radiometrically "hot" rare metal enriched granitoids; Davy et al (1986).

In the central part of the BBF a major alkalic alteration system overprints a clastic trough immediately adjacent to the fault corridor in the Archaean.

10.2 Mineralisation associated with the BBF

The most significant centre of gold mineralisation is Big Bell where a steeply plunging ore system occurs within the BBF. To the west of the BBF in this area is a rare metal rich granitoid. The association of a radiometrically "hot" rare metal granite with amphibolite grade, potash enriched As-Mo-W rich gold mineralisation may have genetic significance at Big Bell; Langsford (1992).

Minor gold mineralisation occurs along splay faults west of the BBF at the Old Prospect Zone (7013000N, 576000E).

In the Dalgaranga Belt gold mineralisation occurs within mafic sequences bounded by major faults which are strands of the BBF. The BBF branches into several major faults west of a 30° clockwise strike change.

11.0 THE WESTERN MARGIN OF THE MURCHISON PROVINCE

The western margin of the Murchison Province adjoins the Western Gneiss Terrain (WGT) which forms the western sector of the Yilgarn Craton; Gee (1979) The WGT is markedly different to the Murchison Province; it has very different geophysical signatures, structural trends and contains much older granitoid and greenstone elements. Important features of the WGT are discussed below.

11.1 Western Gneiss Terrain

The WGT is a mosaic of gneisses, granitoids and minor greenstones. It has a strongly elevated gravity signature compared with the eastern sectors of the Yilgarn Craton, reflecting the thickened mafic granulite layer beneath felsic upper crust; Archibald et al (1981). Major northwest gravity linear features cut the WGT; the most easterly of these is shown on Plate 1. Others are clearly visible on large scale gravity maps; BMR (1992). The northwest gravity linears parallel the geological grain of dykes and faults in the WGT. In the northern part of the WGT arcuate (concave to southeast) gravity trends are also paralleled by geological grain defined by mafic dykes and mapped faults. Aeromagnetic expression of the WGT is much stronger than for the greenstone-granite terrains to the east; granitoids and gneisses show strong but irregular magnetic intensity patterns, more strongly developed in the northern sector.

The WGT contains substantial elements of older felsic crust; gneisses with granitoid, sediment and mafic-ultramafic precursors, 3.7 - 3.4 Ga; Myers (1990); and felsic gneiss (2.8 Ga) with ≈ 3.0 Ga inherited zircons; Pigeon et al (1990). Much of the WGT consists of 2.70 - 2.55 Ga deformed and recrystallised granitoids; Myers (1990); similar in age to the great majority of dates within granitoids outside the WGT.

11.2 **Boundary between the WGT and Murchison Province**

In the north-west part of the map area (Plate 1) the boundary is a major east-west fault, the Yalgar Fault, which separates the Narryer Gneiss (3.4 - 3.7 Ga) from gneissic granites (2.7 - 2.6 Ga) of the Murchison Province. The latter are metamorphosed up to mid amphibolite grade forming the Murgoo Gneiss of Myers, (1990) or pegmatite banded gneiss of Watkins and Hickman, (1990). The granite gneisses are much less deformed and metamophosed than the Narryer Gneiss and do not contain 4.3 - 4.1 Ga inherited zircons.

The Yalgar Fault thus represents a major structural-metamorphic-chronological break between core WGT and a 40-100km wide transitional zone consisting of pegmatite banded gneisses, and small amphibolite grade greenstone belts but containing no younger undeformed ("post tectonic") granitoids.

The eastern boundary of the transitional zone, which is also the overall eastern boundary of the WGT, is defined by strong gravity gradients and a marked change in gravity patterns, to characteristic linear high-circular low greenstone-granite gravity signature. Northeast trending breaks occur in the regional gravity gradient which defines the eastern WGT boundary (Plate 1, 2).

West of the boundary the numerous Proterozoic dolerite dykes trend northeast; east of the boundary mafic dykes are fewer and trend east-west to east-northeast. Watkins and Hickman, (1990). The eastern margin of the WGT does not appear to have a surface geological expression such as a major shear or fault zone. The northern boundary in this sector is however a major thrust fault (Yalgar Fault).

Although the individual north-east trending gravity features in the transition zone can't be matched exactly with individual shears in the Murchison granite-greenstone terrain, it is apparent that at map scale they are parallel, and are probably related in some fundamental way. In particular the Big Bell Fault (BBF) merges with one of the northeast trending gravity breaks in the transition zone. The orthogonal northeast-northwest pattern of the transition zone is also present in the transition zone in lineament compilation maps; Hunting (1968), Hussey and Wright (1982).

The northern part of the Murchison granite-greenstone province corresponds to a marked gravity low (with superimposed short wavelength highs due to greenstone belts) roughly triangular in shape with the apex pointing south, and sides about 200kms long. The regional gravity low corresponds to an area dominated by ovoid granitoid intrusives, the post tectonic suite of Watkins and Hickman (1990). Many of the ovoid granitoids can be clearly seen to intrude the greenstone belts and to form the arcuate portions of granite-greenstone contacts. This indicates a major addition of granitoid material at upper and mid crustal levels.

It is noteworthy that all the major gold deposits of the Murchison fall within the gravity low or on its margins.

In summary the western margin of the Murchison granite-greenstone terrain is a gradational boundary with granite gneiss dominated terrain to the west containing elements much older than that of Murchison terrain, and of higher metamorphic grade. (WGT). The much stronger gravity expression of the WGT is interpreted by Gee et al (1981) as due to a thickened mafic granulite layer in the lower crust.

At a craton scale this boundary is fundamental, reflecting significant crustal variation; geophysically it is much more obvious than other terrain boundaries presently predicated within the Yilgarn Craton eg. Gee (1990).

12.0 NORTHERN MARGIN OF THE YILGARN CRATON; Relationships between Archaean granite-greenstone basement and Proterozoic Basins

In the eastern part of the northern margin of the Yilgarn Craton, Archaean rocks are covered by two Proterozoic Basins; the ≈ 1.9 Ga Glengarry Basin and the ≈ 1.7 Ga Nabberu Basin. Overall this sector of the craton margin has the form of a north-northwest directed arrowhead with the Wiluna Arch forming the shaft. (Plate 1)

The Nabberu Basin; Bunting (1986), to the east of the Wiluna Arch, covers a 100-120km wide sector of the craton. Greenstone and granite belts can be traced, by their characteristic aeromagnetic and gravity signatures, beneath the sedimentary cover rocks. (Plate 2)

Major 300° trending structures control the form of the Nabberu basin east of the Wiluna Arch; the structures, defined by aeromagnetics and gravity trends, form part of a continent scale lineament corridor (G9C) initially recognised by O'Driscoll (1989). Individual geophysical lineaments up to 1000km long occur within the lineament corridor.

Three main 300° breaks can be identified geophysically within Archaean basement to the Nabberu Basin. The most southerly closely corresponds to the exposure of unconformity between the sediments of the basin and Archaean greenstone-granite. A 20km wide zone of small scale faults and aeromagnetic linears straddles and parallels the (remarkably linear) unconformity. Flexures of greenstone and granite belts, and small scale offsets on magnetic markers indicate sinistral movement, this is supported by sinistral displacement on east-west faults south of the unconformity (Plate 2). The Teague Ring structure; interpreted to be a 1630 Ma intrusive complex; Bunting (1986), occurs within this belt. (section 4.2)

A central structural belt marked by aeromagnetic and gravity alignments and bends in greenstone granite belts (Plate 1, 2) corresponds to the northern limits of the gently folded shallow northeast dipping frontal sector of the Nabberu Basin; Kingston Platform of Bunting (1986). The persistence of aeromagnetic features related to greenstone lithologies indicates that Proterozoic cover is relatively thin ≈2-3 kms over much of this sector; see also Windh (1992) Appendix 4. Further north magnetic expression "fades" but gravity patterns clearly indicate that the granite-greenstone basement continues. Within this sector; Stanley Fold Belt, Bunting (1986), Gee (1990); the cover rocks are strongly cleaved, tightly folded (with much overturning and axial plane breakthrusts) and metamorphic grades are mid-upper greenschist facies; Gee (1990).

The northern structural zone clearly marks the margin of the Yilgarn Craton; both the diffuse but characteristic aeromagnetic, and strong gravity patterns are truncated by 300° trends. A granite inlier (Malmac) of inferred Archaean age occurs along the structural zone, as does a slice of possible Glengarry Group sediments. (Troy Creek Beds). The zone closely corresponds to the present position of the unconformity with younger Bangemall Group. In the northwest, near the Wiluna Arch, Nabberu Basin sediments are unconformable on Archaean granites.

Contrasting deformation styles in the northern and southern sectors of the Basin are reflected in the geophysical expression of basement; in the south no evidence of major deformation or shortening; in the north there is evidence of breaking up and northeast-southwest shortening of basement. Basement shortening is more pronounced towards the Wiluna Arch, and some basement decollement may have occurred to accommodate the extreme shortening of the cover sequences as shown by the fold styles, ie. overturned folds and thrust faults.

Nabberu Basin sediments cross the Wiluna Arch, where the trend of the basin axis changes from northwest (east of the Wiluna Arch) to northeast (west of the Wiluna Arch. Plate 1). This 90° anticlockwise bend in the basin axis across the Wiluna Arch also occurs in the Archaean granitoid "basement". If the Troy Creek Beds are equivalent to the Glengarry Group an identical 90° strike rotation occurs in the Glengarry Group units also (Plate 1).

Nabberu Basin sedimentation was entirely ensialic, and devoid of volcanics. The present craton margin north of the Nabberu Basin is a major sinistral transcurrent/transpressional zone, with major displacement post Nabberu-pre Bangemall. (1.8 - 1.6 Ga) The nature of basement to the Bangemall Basin is not known.

12.1 Glengarry Basin

This 1.9-1.8 Ga basin is east of the Wiluna Arch; Windh (1992). Sequences within this basin contrast strongly with those of the Nabberu Basin, containing abundant mafic-ultramafic volcanics, (Narracoota Formation) and a core of amphibolite facies grade rocks. (Peak Hill Metamorphics) Like the Nabberu Basin the Glengarry Basin is ensialic but the presence of mantle derived mafic-ultramafic sequence; Hynes and Gee (1986) indicates significant rifting.

The Glengarry Basin contains two contrasting lithological packages. In the southeast; the Paroo Platform of Gee (1990) are relatively undeformed basal clastics, overlain by tholeiitic volcanics and subvolcanic intrusives; and shale-carbonate units. Nabberu Basin units (Earaheedy Group) occur as thin patches on the Glengarry Group.

The northwest part of the Glengarry Basin contains sequences much more deformed, and metamorphosed up to amphibolite grade; Windh (1992). The mafic-ultramafic volcanics are generally altered and are geochemically distinct from those to the southeast; Hynes and Gee (1986).

Contrasts in lithology, structural style and metamorphism indicate that a major structural break occurs between the two elements of the Glengarry Basin. This is confirmed by geophysical signatures of Archaean "basement" to the Proterozoic.

The southeastern sector is mainly underlain by granite-greenstone terrain, shown by the characteristic ovoid low and linear high gravity signature. This interpretation is supported by aeromagnetics, although signatures are partly masked by the overlying Proterozoic.

The Archaean basement of the south-eastern sector can be further divided. In the west, the extension of the Meekatharra Greenstone Belt, rotated clockwise, can be recognised. The central portion is a continuation of granitoid terrain exposed south of the Proterozoic unconformity; this sector is bounded by the ETZ (west) and KKL (east). To the east is the covered extensions of the Wiluna Greenstone Belt (Plate 1).

Gravity and aeromagnetic patterns indicate that to the north of the central portion is a sector older gneiss, similar to that north of the Yalgar Fault. The east-west contact (approximately 708000N) is interpreted as the northern limit of autochthonous Yilgarn Craton greenstone-granite terrain.

North of the gneiss sector basement is interpreted to be granite-greenstone, exemplified by the characteristic ovoid gravity lows due to granitoid masses including the exposed Goodin Dome. This granite-greenstone sector is interpreted to be a continuation of the Wiluna Greenstone Belt. The overall signature of ovoid gravity lows and short wavelength gravity highs in this sector is very similar to parts of the Archaean Pilbara Craton, rather than the linear signatures of the Yilgarn Craton.

To the north of the sector interpreted as the continuation of the Meekatharra Greenstone Belt is a major gravity high which is interpreted to be caused by Narryer Gneiss basement. The approximately east-west trends of this block are along strike from exposed Narryer Gneiss to the west and separated from it by a major north-northwest trending structure, marked by a very strong gravity gradient. This trend is parallel to the major structural grain of the Eastern Goldfields Province, and to the KKL 110 kilometres east.

A strong gravity gradient zone forms the northern margin of the inferred Narryer Gneiss block; this gradient marks the northern margin of the interpreted "thick" Archaean basement. The gravity gradient zone corresponds with tightly folded synclinal basins of iron formation units (Robinson Range Formation; Windh (1992), and further to the east, with a thrust contact between Proterozoic sequences and Archaean granitoids; Windh (1992).

North of this major thrust is a series of thrust stacked Archaean granitoid sheets including the Marymia Belt. There is a significant change in "basement" shown by the major gravity low to the north; the cause of this large low is not known at present. It may be due to thick keel of reworked Archaean-Proterozoic granitoid gneiss.

The Marymia Belt (often called the Marymia Dome) is in structural contact with the north-east trending northern margin of the Glengarry Basin; the "Dome" is certainly Archaean granitoid with a minor greenstone component but does not have the gravity expression of an autochthonous greenstone-granite terrain. Deep exploration drilling at Plutonic Mine, (D. Hall pers comm) and at other exploration sites (Marymia Exploration NL 1994) have shown that the Marymia Belt consists of stacked thrust slices of granite-greenstone. Transport direction is towards the southeast. These observations confirm that the Marymia Belt is a relatively thin allochthonous unit. Basement to the Marymia Belt is interpreted to be the same as that for the highly deformed western portion of the Glengarry Basin ie. a complex reworked Archaean-Proterozoic gneiss terrain; Gascoyne complex - see Myers (1990).

The Marymia granite-greenstone belt and the Copper Hills (Proterozoic) belt are interpreted here to be made up of imbricated northwest dipping thrust slices. The slices are thrust against a rigid autochthonous Archaean greenstone-granite mass beneath the southern part of the Glengarry Basin. This interpretation is consistent with,

1. The confirmed presence of southeast directed granite-over-greenstone thrusting in the greenstone Marymia Belt.

2. The consistent northwest dip of foliations and quartz filled fault zones in the Marymia Belt.

3. The geophysical evidence that the greenstone components are thin sheets at Marymia and Baumgarten.

4. The allochthonous nature of the arcuate Copper Hills Belt.

5. Tectonic interleaving of Archaean granitoids Early Proterozoic, gneiss and Peak Hill metamorphics; Windh (1992).

Available widespaced geological, geophysical and remote sensing information suggest that granitoids of the Marymia Belt are best matched with those east of the Wiluna Arch. The slices of Archaean granite-greenstone now forming the Marymia Belt are interpreted here to have been sinistrally displaced along 300° structures, from the margin of the Yilgarn Craton now beneath the Nabberu Basin. This requires about 90° of anticlockwise rotation, which is congruent with the flexure in Nabberu Basin sediments across the Wiluna Arch. This rotation occurred post Nabberu-pre Bangemall ie. $\approx$ 1.8 - 1.6 Ga.

The interpretation made here is that basement of the Glengarry Basin (as defined by Gee (1990) north of about 7080000N is a collage of granite, gneiss and granite greenstone terrains. Major north-northwest trending structures bound the accreted sector.

North of a major east-north-east gravity gradient zone the Glengarry Basin is bounded, and partly underlain, in the west, by northwest dipping thrust sheets of Archaean granitoid including the Marymia Belt. The most northerly tectonic slice is the Proterozoic Copper Hills Belt of unknown provenance.

A major difference in tectonic style occurs either side of the Wiluna Arch. To the west, Archaean basement to the Proterozoic Glengarry Basin is a mosaic of accreted granite, gneiss and granite-greenstone; further north is a thrust belt of Archaean granitoids and Proterozoic sediments. East of the Wiluna Arch basement to the Nabberu Basin is autochthonous granite-greenstone cut by sinistral east-northeast faults.

Recognition of accretionary tectonics within basement to the Glengarry Basin, (and possibly within Proterozoic cover rocks also) places the mesothermal gold deposits of the Glengarry Basin in an environment comparable with Canadian Cordilleran and Californian "Motherlode" gold deposits; Nesbitt (1991); Landefeld, (1988).

The zone of accreted blocks is bounded to the east and west by north-northwest trending structures marked in the basement by gravity breaks. The eastern gravity break is parallel to the KKL and other major structures within the Norseman-Wiluna Belt; it also is parallel to and close to post-Nabberu Basin Faults such as the Merrie Range Fault.

13.0 DISCUSSION

13.1 Inheritance

Long complex structural zones of the type discussed here are common features of Archaean (and Lower Proterozoic?) granite-greenstone terranes. Provinces with high gold endowment such as the Yilgarn Craton, the Superior Province and granite-greenstone terrains in Africa have numerous LSZ; Groves et al (1989): Vearncombe et al (1989).

Within the Yilgarn Craton the mappable expression of the LSZ is the result of the interaction of several different tectonic episodes. East-northeast to west-southwest shortening, which is the D_2 deformation of all tectonic synthesis; Hammond and Nisbet (1992); Williams and Whittaker (1993); Passchier (1994) is the dominant structural style giving the Eastern Goldfields its characteristic north-northwest grain. Structural grain defined by upright regional folds in the Murchison province is dominantly north-northeast (Plate 1) indicating that the direction of shortening was east-southeast to west-northwest; this is also related to a D_2 tectonic phase; Grigson et al (1990); Wang et al (1993). The Edale Tectonic Zone (ETZ) forms the boundary between these two domains of different structural grain, and is interpreted here to be a Province Boundary, separating the Murchison Province (west) from the Southern Cross Province (east).

There are a range of tectonic models for the early evolution of the Yilgarn, ranging from accretionary "plate tectonic" models, Barley et al (1993); Myers (1992), rift models, Groves and Batt (1984); and core-complex style crustal extension: Hammond and Nisbet (1992); Williams and Whittaker (1993).

The acceptance of the major D_2 shortening or transpressional event is independent of the acceptance of any "pre-shortening" evolution model; the orientation of tectonic farfield forces was probably radically different in each case and the events may well be, in the broad sense, unrelated. A concise review of the various tectonic models is given in Passchier, (1994).

Evidence is mounting however that extensional tectonics had a major role in the pre D_2 evolution of the Yilgarn granite-greenstone terrain; Hammond and Nisbet (1992); Williams and Whittaker (1993); Williams and Currie (1992). This model allows rationalisation of several large scale relationships important at map scale.

Large slices of granitoid and gneiss in the Murchison Province, such as that west of the Meekatharra Belt, and the folded slice east of Mt Magnet (Plate 1) were, in the extension model, emplaced within greenstones during early extension; Hammond and Nisbet (1992); Williams and Whittaker (1993; Table 1). The even larger coherent granitoid slices (200kms long), east of the KKL (7070000N to 6920000N) is interpreted here to have a similar emplacement history. Dating of the slice east of Mt Margaret confirms its Pre D_2 age; Wiedebeck and Watkins (1993).

Hammond and Nisbet (1992, fig 2) suggest that many shear zones parallel to the "grain" of granite-greenstone belts are early low angle structures (lags) steepened and reactivated by D_2 shortening. The steepened structures were then overprinted by several periods of strike-slip faulting. This interpretation explains some observed properties of LSZ, such as the occurrence of adjacent zones of steep and shallow plunging extension lineations and variable sense of movement along adjacent sectors.

In particular the presence of LSZ along or close to the margins of major granitoid gneiss complexes can be explained by this mechanism. An example is the granitoid complex; Laverton Domain of Whitaker (1993) bounded by the CL (west) and DLS (east) north of 6820000N, Plates 2 and 3. The complex shear zones are here interpreted to be steepened, reactivated, extensional low angle shear zones related to the emplacement of the Laverton Dome of Williams and Whitaker (1993). Both of the steepened zones have been overprinted by sinistral strike slip faults; Langsford (1990), Keele (1992).

Another example of such reactivated steepened zones along gneiss granite complex is the SZ north of 6650000N, west of the Riverina Gneiss. It is important to note that not all of the LSZ, or even all parts of any particular LSZ have such origins. Only those early structures in suitable orientations for reactivation, and in places overprinting by strike slip faulting, become parts of LSZ.

Another aspect of possible inheritance from pre D_2 structures involves transfer faults. If, as suggested by Hammond and Nisbet (1992, pp 41) approximately north-south extension and thrusting occurred, then transfer faults (sub) parallel to this direction could be expected; these are likely to be deeply penetrating structures. The normal rift model does not apply to the Yilgarn (see Passchier (1994) for review) during the formation of the volumetrically dominant 2.72 - 2.69 Ga; Swager et al (1992) supracrustals but may have been important during the earlier volcano-sedimentary episode at 2.94 Ga; Hill et al (1992). The earlier supracrustals formed directly on older sialic crust. Reactivation of transfer faults formed in such early ensialic extension environments could lead to the development and propogation of major structures through thick supracrustals deposited during the later episode (2.72 -2.69 Ga). Important structures of this type such as the BLF occur within extensive coherent greenstone belts such as the southern part of the Eastern Goldfields which is up to 75km wide, bounded to the east by the KKL.

The southern part of the ZS is possibly of this style (south of 6640000N). Direct detection of the "parent" transfer fault would require much more detailed gravity and seismic data than is presently available. Although not discussed here as a LSZ, the Boulder-Lefroy Fault (which is the locus for giant gold deposits) may also be related to a reactivated transfer fault. It is not a reactivated "lag" structure; is clearly not a "boundary" structure of any kind as it has the same coherent stratigraphy on each side; Langsford (1989) and terminates along thrusts directed towards the central part of the fault; see Swager et al (1992), Fig 3.

The BLF is here interpreted some sort of flower structure propagating from a relatively short basement structure which originated as a transfer fault.

13.2 LSZ as Province, Terrane and Domain boundaries

Whatever are the origins of LSZ, several of those described in this report are logical Province boundaries. The ETZ forms a geologically appropriate western boundary to the Murchison Province; west and southwest of the ETZ structural grain is north-northeast rather than north-northwest; and no large layered sill complexes occur north of the ETZ. The position of the eastern boundary of the Southern Cross Province is logically placed west of the Riverina Gneiss Complex. Previous Province boundaries were arbitrarily drawn; Meyers (1990).

The KKL forms the Southern Cross-Eastern Goldfields Province boundary north of 7025000N (see section 5 and Plate 3). South of 6750000N the same Province boundary is essentially along the ZS (see section 6.0 and Plate 3). Along much of its length the KKL forms the eastern boundary of the Eastern Goldfields Province. The main differences between Provinces east and west of the KKL have been documented in section 5.2. On craton scale geophysical aeromagnetic and gravity images the trace KKL is a major welt, truncating structural trends on either side.

In general the LSZ do not coresopnd to proposed Province; Terrane or Domain boundaries, the exceptions being the ETZ and KKL (Province Boundaries) and ZS (Domain Boundary); Swager et al (1992).

13.3 Late structural signatures of LSZ

The most readily decipherable aspects of the LSZ are those which relate to their late geological history. It is emphasised that the LSZ are not simply strike slip faults but complex zones with different structural histories along their lengths; it is their post D_2 histories which have most commonality.

Most of the LSZ have some late fault controlled elongate basins containing relatively coarse clastic sedimentary units. Where well documented the basin fill contains clasts of mainly local provenance. The KKL for example has a belt of conglomerates about 220 km long; the BBF, CF and DLS also have extensive linear coarse clastic basins associated.

The presence of the basins indicates that both local uplift and extension occurred during the late stages of compression (transpression?). In all cases shear zones cut the sediments showing that strike slip movement persisted. No satisfactory age dating of this sedimentary accumulation and subsequent strike slip episode is available.

Strong potassic alteration and associated porphyry intrusion is documented from the sediment trough along the BBF (section 10.1). Centres of intense carbonate alteration are associated with the conglomerate trough along the KKL in the Porphyry district (Plate 3, section 5.0). The association of coarse clastics, alkali intrusions and metasomatism, and carbonate alteration is probably more widespread along the LSZ that at present known, owing to poor exposure. Numerous pinpoint aeromagnetic features along the CL are interpreted to be small alkaline felsic or ultramafic intrusives; Langsford (1990).

Plugs of undeformed alkaline syenites (Johnson 1991) occur along the southern part of the CL; to the north the CL bounds a major belt over 200kms long of late stage alkaline granitoids; Libby (1987). These have a characteristic aeromagnetic and gravity signature. (section 4.2). The LSZ in the Eastern Goldfields - Northeastern Goldfields, particularly the CL, are closely to broadly associated with late (≈2500 Ma?) alkalic felsic intrusives. This association is poorly developed in the Murchison Province. Libby, (1987) and Johnson (1991) interpret the alkalic syenites to be intruded along deep, crustal scale structures. Plugs and dykes of quartz syenite and alkalic syenite are intruded along the faulted eastern margin of the KKL in the Leonora area; Hallberg (1985). If the interpretations of mantle signatures in the late intrusives; Libby (1987), Johnson (1991) are correct, then the LSZ were deeply penetrating structures during their late history. This is supported by seismic evidence (see section 6.2).

Within the Murchison Province the MES and MMS bound a coherent synclinal sector of stratigraphy. The two shear zones and the coherent package between them are a remarkably linear belt 150 kms long, forming a major geological boundary in the Murchison Province (section 8.1). Late dextral movement along this belt, and its south-western extension can be clearly seen; (Section 8.0, Plate 1) this movement post dates the CF and the youngest granitoids; Wang et al (1993); Plate 1. Clearly there has been late brittle strike slip reactivation of a complex structural corridor.

13.4 Gold Mineralisation and LSZ - a brief review

There are only a few large meso-to epizonal gold deposits in the Yilgarn directly hosted by LSZ - the largest being Big Bell within the BBF (100 tonnes Au); the Mt Morgans deposit (40 tonnes Au) occur within a strike slip strand of CL. Numerous smaller deposits do occur within LSZ. The common feature at each of the gold mineralised zones is the occurrence of a recognisable (though often subtle) flexure in the LSZ. (See sections 3.2; 4.2; 5.1). Conversely the structure associated with the largest known gold systems in Yilgarn, the BLF (Golden Mile District >2000 tonnes Au, St Ives >300 tonnes Au) is <u>not</u> a LSZ in the sense of this report (section 13.1). LSZ in themselves are not a necessary or sufficient ingredient for the formation of large meso-to epizonal gold deposits.

Several major gold deposits are very close to LSZ or within structural corridors defined by LSZ. In the Murchison Province the Mt Magnet field (>100 tonnes Au); Reedy's (>30 tonnes Au) and the Meekatharra district (>60 tonnes Au) occur within the MES-MMS corridor; individual mineralised shears are linked to the main structures (section 8.2).

In the Leonora district the Sons of Gwalia Mine (>100 tonnes Au) occurs along the western edge of the KKL (5-10km wide in this sector) in a complex zone of intersecting splay structures and reactivated low angle structures (section 5.0).

Large gold deposits occur on splay faults, or faults linking two LSZ; these deposits can be quite distant (>10 kms) from the nearest LSZ. The Wiluna field (>200 tonnes Au) is controlled by strike-slip splays which propagate from a flexure in the KKL (section 5.0); the Granny Smith field (>60 tonnes Au) occurs along a link structure joining the CL and DLS (section 4.1). The Redeemer district (>60 tonnes Au) is controlled by the Waroonga Shear which splays from a flexure in the KKL section 5.0. The Higginsville district (>30 tonnes Au) is controlled by splay-faults from the SZ (section 6.0).

There is no apparent systematic difference between the gold deposits linked to LSZ and those that are not; there are structures in the Yilgarn other than LSZ which can tap the hydrothermal fluid reservoir required to produce large gold deposits.

13.5 **Proterozoic activity**

In the northern part of the Yilgarn Craton there is evidence for Proterozoic activity along the LSZ. A large Proterozoic carbonatite complex occurs adjacent to the DLS (Mt Weld Carbonatite). The post Nabberu sedimentation Teague syenite complex (≈1600Ma?) is adjacent to the CL and is a geological extension of the alkaline intrusive belt east of the CL (Plate 2; section 4.2). Linear fault zones corresponding to the CL (Horse Well Fault) offset Nabberu sediments (Plate 2).

It is clear that no significant movement occurred along any of the LSZ in the southern part of the Yilgarn Craton after the emplacement of the Widgiemooltha mafic dyke suite at ≈2.4 Ga.

14.0 SUMMARY

1. LSZ are complex, hundred of metres to several kilometres wide zones with strongly developed ductile to brittle fabrics. Detailed structural investigations are hampered by generally poor exposure. At this stage no coherent picture of structural evolution has emerged.

2. The LSZ have had a variable Pre D_2 history. Some are reactivated, steepened low angle structures, originally both extensional or compressional; others originated as steep, faults possibly transfer faults, or as early (growth) faults controlling volcano-sedimentary basins or centres.

3. LSZ have been reactivated by several generations of strike slip faulting. The strike slip faults exploited individual strands of much wider complex LSZ.

4. LSZ have one or more of these late stage associations; belts of alkaline felsic intrusives; linear troughs of coarse clastics; alkaline or carbonate metasomatism; strongly radiometric rare metal granitoids.

5. Some LSZ coincide in part with Province Terrane or Domain Boundaries.

6. Although only a few major gold deposits are within LSZ, the latter are a primary element of the structural hierarchy which hosts all the meso-to epizonal gold deposits of the Yilgarn.

To the north of the sector interpreted as the continuation of the Meekatharra Greenstone Belt is a major gravity high which is interpreted to be caused by Narryer Gneiss basement. The approximately east-west trends of this block are along strike from exposed Narryer Gneiss to the west and separated from it by a major north-northwest trending structure, marked by a very strong gravity gradient. This trend is parallel to the major structural grain of the Eastern Goldfields Province, and to the KKL 110 kilometres east.

A strong gravity gradient zone forms the northern margin of the inferred Narryer Gneiss block; this gradient marks the northern margin of the interpreted "thick" Archaean basement. The gravity gradient zone corresponds with tightly folded synclinal basins of iron formation units (Robinson Range Formation; Windh (1992), and further to the east, with a thrust contact between Proterozoic sequences and Archaean granitoids; Windh (1992).

North of this major thrust is a series of thrust stacked Archaean granitoid sheets including the Marymia Belt. There is a significant change in "basement" shown by the major gravity low to the north; the cause of this large low is not known at present. It may be due to a thick keel of reworked Archaean-Proterozoic granitoid gneiss.

The Marymia Belt (often called the Marymia Dome) is in structural contact with the north-east trending northern margin of the Glengarry Basin; the "Dome" is certainly Archaean granitoid with a minor greenstone component

A major difference in tectonic style occurs either side of the Wiluna Arch. To the west, Archaean basement to the Proterozoic Glengarry Basin is a mosaic of accreted granite, gneiss and granite-greenstone; further north is a thrust belt of Archaean granitoids and Proterozoic sediments. East of the Wiluna Arch basement to the Nabberu Basin is an autochthonous granite-greenstone terrane, cut by sinistral east-northeast faults.

Recognition of accretionary tectonics within basement to the Glengarry Basin, (and possibly within Proterozoic cover rocks also) places the mesothermal gold deposits of the Glengarry Basin in an environment comparable with Canadian Cordilleran and Californian "Motherlode" gold deposits; Nesbitt (1991) Landefeld, (1988).

The zone of accreted blocks is bounded to the east and west by north-northwest trending structures marked in the basement by gravity breaks. The eastern gravity break is parallel to the KKL and other major structures within the Norseman-Wiluna Belt; it also is parallel to and close to post-Nabberu Basin Faults such as the Merrie Range Fault.

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17.1 **Appendix 1 - Map Compilation procedure**

Scale

The 1:500,000 scale was selected for two reasons. Firstly, it is the largest scale at which the entire Yilgarn can be presented. At any larger scales the sheet area is too large for convenience.

Secondly, it is the smallest scale at which fundamental lithological packages, major second order structures, important greenstone-granite relationships and granitoid types can be presented and distinguished. At this scale almost all gold deposits or clusters of occurrences can be shown, in relationship to major geological features.

Data Sources

Published GSWA 1:250,000 sheets listed below are the fundamental ingredient of the 1:500,000 maps. BMR/ASGO 1.6km spaced aeromagnetics and 11km spaced gravity data were used to produce the skeleton interpretation. In each case coloured and greyscale images prepared by Newcrest Geophysical Department were used.

Where more detailed information was available this was used, this information fell into categories:

1. 1:100,000 scale GSWA geological mapping, available for part of the Eastern Goldfields.

2. 200m spaced Aerodata magnetics available for parts of the Eastern and NE Goldfields; and 400m spaced ASGO aeromagnetics available for SIR SAMUEL.

3. Isolated geological data available from inhouse geological reports, company reports and published material; hundreds of "fragments" of geological information were generalised and photoreduced to map scale for incorporation.

4. Systematic 1:25,000 mapping by J.A. Hallberg (see references). This high quality fact mapping was used in the Murchison map and for part of the NE Goldfields.

5. Geological mapping compilations and interpretation at various scales made by the writer in the Eastern and NE Goldfields; together with hundreds of (at this scale) "single point" observations made during mine visits, project work, prospect evaluation and regional traverses.

Compilation Procedure

To produce an interpretative skeleton, 1:250,000 scale GSWA maps were accurately photoreduced in blocks for each of the 3 map sheets and fitted with an AMG grid. Firstly, the greenstone belts were outlined, with the aid of images derived from BMR ASGO 1.6km spaced aeromagnetics, and BMR/ASGA 11km spaced gravity data. "Greyscale" images proved to be the most useful aeromagnetic image. Gravity data is essential to define greenstone belts; many past Yilgarn compilations are in error because of failure to use gravity. Gravity data is essential for tracing the extent of greenstone belts below Proterozoic basins in the north, and hence locate the true craton margin.

Major granitoid subunits and gneiss belts can be outlined using the BMR/ASGO aeromagnetics and gravity; exposure is generally too poor to do this from geological data alone.

The outline of the green belts can then be fleshed out by recognising major lithological packages, magnetic markers, internal granitoids etc. Geological trend lines - contacts or strike lines from geological maps, and magnetic markers were added together with major "internal" contacts (between mapped packages or distinct magnetic units, or between greenstones and internal granitoids). The major map units were selected on the basis of "plotability" at map scale; importance in gold exploration (the aim of the compilation) recognisability in aeromagnetics and consistency across the various sheets.

The broad brush interpretation forms a setting into which a mosaic of fragments of more detailed geological information and "sub interpretations" can be fitted. The process I call finessing - naturally it is never completed.

A vast amount of geological "fact" and interpretation is available in the Yilgarn mainly derived from the two great waves of mineral exploration - the nickel and gold (1968-1973) and gold (1983-199..?) booms and to a lesser extent the VMS exploration phase of the late 1970's.

Large areas are also covered with detailed aeromagnetic surveys, although not all this was available. Colour and grey scale images of this detailed magnetics were used to assist in the finessing.

Finessing consists of five steps - collection; assessment; reduction; generalisation; integration. Collection is the capture of data at all scales from every available source. Assessment is the evaluation of the utility of the data for the purpose at hand and its "accuracy". Reduction is the physical photoreduction of the data to required scale (it is amazing how often scales are wrong on maps or figures). Generalisation is the simplification of "excess" detail into usable map units and smoothing of structural details to suit map scales. Integration is the fitting of each of the data fragments and making them fit with the pre-existing information; often this requires re-examination of the pre-existing information assemblage; revisions are frequent at this stage.

The finessing process is interactive and often the fitting of one data fragment will require seeking out of more information adjacent to it, or force a re-interpretation.

Major structural zones are based on mapped shear zones, geophysical alignments or gradients and geological dislocations. In part they are identical to those well established in the existing literature.

Second order structures are interpreted from geological or aeromagnetic truncations or deflections, mapped quartz "blows" or geological terminations not better interpreted as lithological interfingering.

Presentation

Maps were compiled by hand on film transparencies at 1:500,000 scale controlled by AMG grids, and hand coloured to check consistency and correctness of unit boundaries.

Maps were then digitised in Newcrest's Belmont Exploration drafting office, using Microstation Version 5, with Cadscript as a peripheral package.

17.2 Appendix 2 - GSWA sheets used as interpretive base.

Base

1:250,000 sheets GSWA

Plate 1

Robinson Range	50-7
Peak Hill	SG 50-8
Belele	SG50-11
Glengarry	SG50-12
Cue	SG50-15
Sandstone	SG50-16
Kirkalocka	SH50-3
Youanmi	SH50-4

Plate 2

Nabberu	SG51-7
Stanley	SG51-6
Wiluna	SG51-9
Kingston	SG51-16
Sir Samuel	SG51-13
Duketon	SG51-14

Plate 3

Leonora	SH51-1
Laverton	SH51-2
Menzies	SH51-5
Edjudina	SH51-6
Kalgoorlie	SH51-9
Kurnalpi	SH51-10
Boorabin	SH51-13
Widgiemooltha	SH51-14
Lake Johnston	SH51-1
Norseman	SH51-2

Geophysical Images

Prepared by Geophysical Department, Newcrest Mining using ASGO (BMR) data.

Meekatharra East 1:500,000 M. Flis, 1989 T.M.I. Colour

Meekatharra East 1:500,000 M. Flis, 1989 T.M.I. Greyscale

Meekatharra East 1:500,000 M. Flis, Bouger Gravity (2.67 g/cc) colour

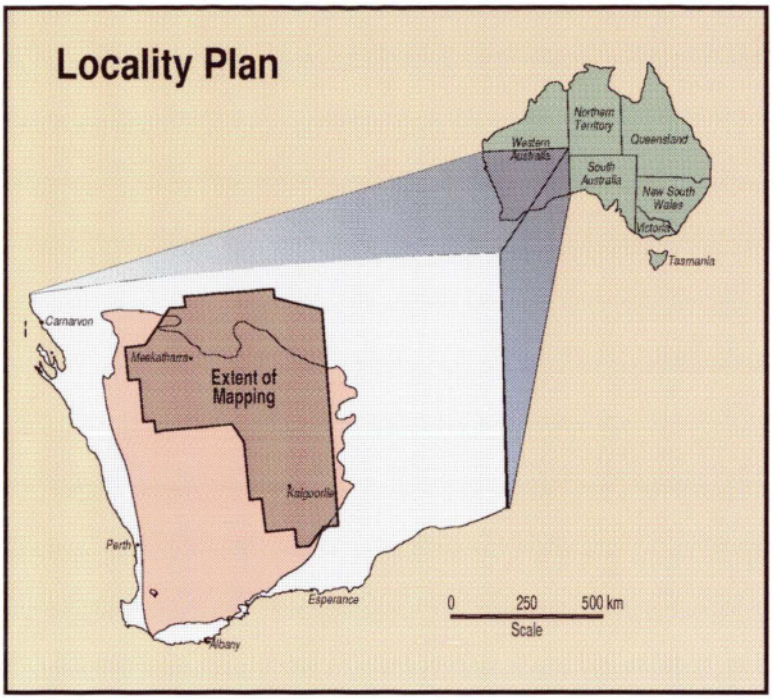
Wiluna West 1:500,000 M. Flis, 1989. T.M.I. colour

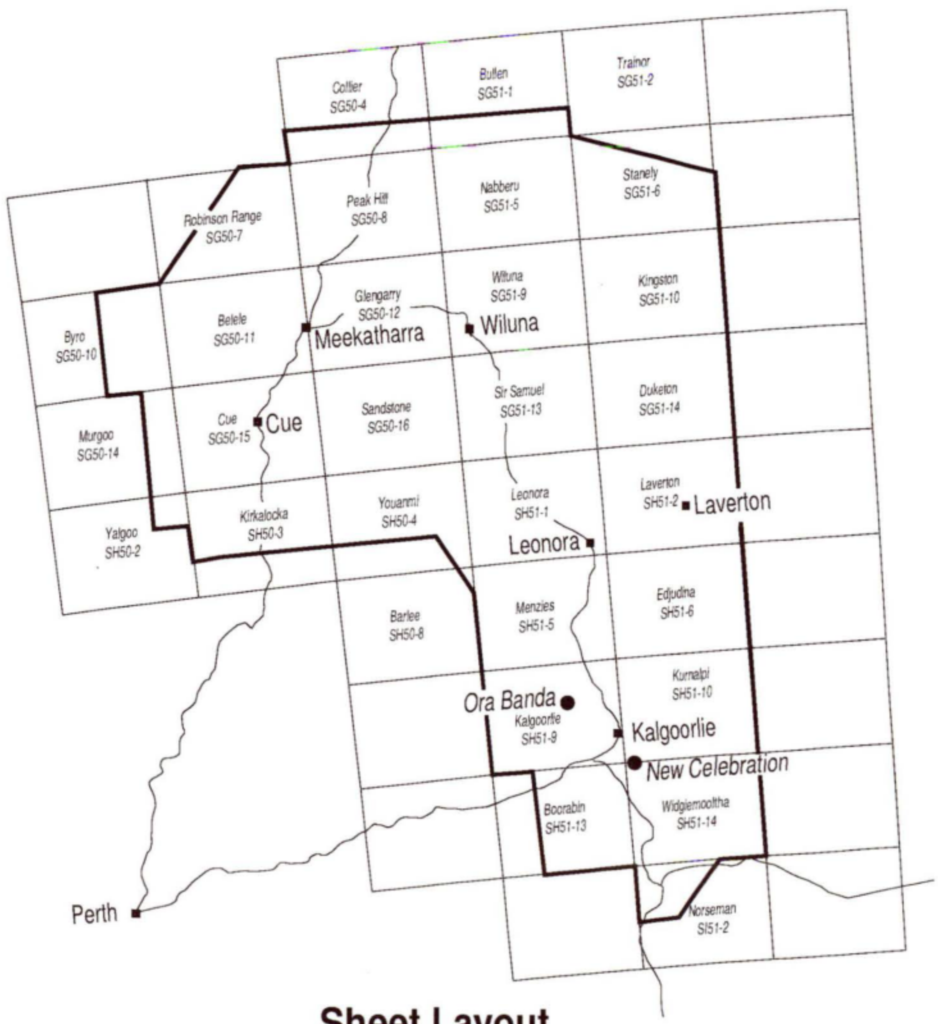
Wiluna West 1:500,000 M. Flis, 1989. Bouger Gravity (2.67 g/cc) colour

Norseman-Wiluna 1:500,000 M.A. Sexton 1988, TMI colour

Boorabin - Laverton 1:500,000; Gravity; Bouger Density (2.67 g/cc) colour

Norseman Wiluna 1:500,000 M.A. Sexton 1988. T.M.I. Greyscale





Sheet Layout
1:250000 Sheet Index